ELEKTOR ELECTRONICS

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Focus on: Computer memory chips

18 24
32 40
46 57
69 70
73

PC SOUND CARD AS AF ANALYSER

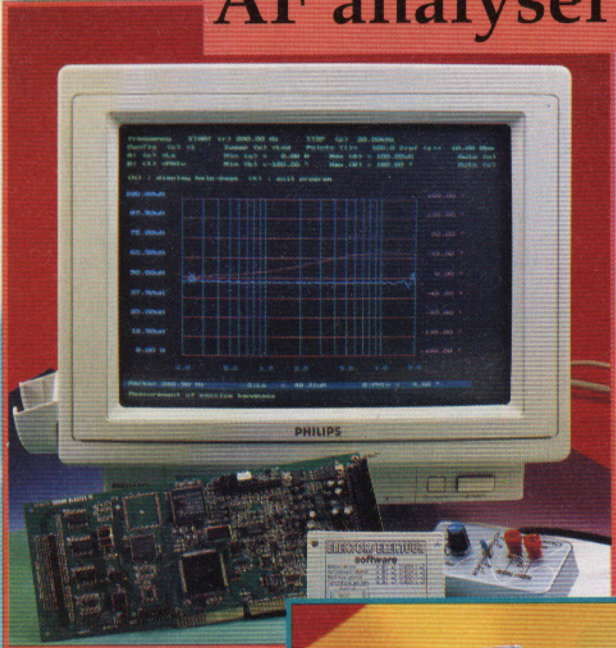
SATELLITE FINDER

HOUSEPLANT BUZZER

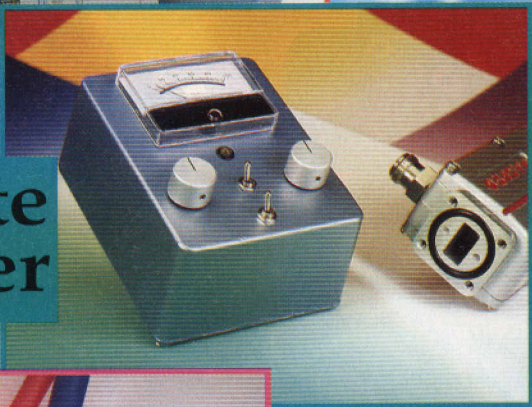
9 770268 451050 03

ELEKTOR ELECTRONICS

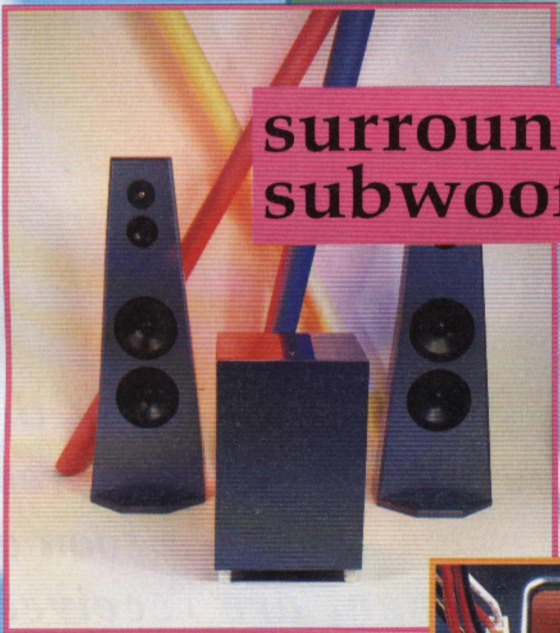
PC soundcard as AF analyser 40



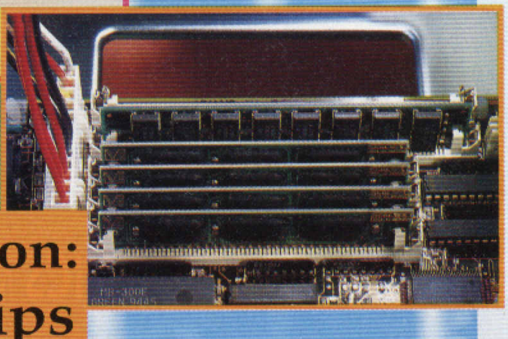
52 satellite finder



surround-sound subwoofer 62



18 focus on: PC memory chips



CONTENTS

March 1996 Volume 22
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Eurofighter engineer is 1995 Young Woman Engineer of the Year

A twenty-nine year-old senior avionics systems engineer with British Aerospace, Pamela Wilson, was chosen as the Young Woman Engineer of the Year at a ceremony held in London in January.

Pamela, who already regularly visits schools and colleges to explain her interesting job, told *Elektor Electronics* at the award presentation: "I went into electronics because I was interested in how things worked."

A graduate member of the IEEIE, Pamela was runner-up for the 1992 Young Woman Engineer of the Year Award and this time she was voted by the judging panel top of the six finalists and was presented the coveted award for 1995, a cheque for £ 750 and a silver rose bowl.

Pamela joined the Military Aircraft Division of British Aerospace Defence at Wharton Aerodrome, Preston. Her two-year graduate training involved placement in equipment engineering, research and development and system design. As a result of her final training placement, she stayed with the Eurofighter 2000 cockpit group where she was promoted to Avionics Systems Engineer. Her work is primarily defining the man-machine interface requirements for the sensors control within the EF2000 cockpit.

Pamela is the eighteenth recipient of the Award, which is jointly sponsored by the Institution of Electronics and Electrical Incorporated Engineers (IEEIE) and the Caroline Haslett Memorial Trust (CHMT). The aim of the Award is to highlight electronic and electrical engineering as a rewarding and worthwhile career for women. Previous winners and contenders for the Award have more than proved that women make extremely competent electronic and electrical engineers at Incorporated Engineer level — a career once almost exclusively male-dominated.

Prior to the winner being announced, a video of all six award finalists at work was shown to representatives from industry, commerce, academia and media who attended the ceremony whose organizers still see a crying need for the event in years to come.

Runner-up for the 1995 Award and winner of the WISE prize was Audra Gittens, a 28-year-old test engineer with Robinson Instruments, Runcorn, Cheshire. Audra, a graduate member of the IEEIE, was presented with a cheque for £ 500.

Third-prize winner, Rosemarie Haycroft, received a cheque for £ 250. Rosemarie, 27, is a switch maintenance engineer with Cellnet Mobile Communications and is based at the Manchester Switch Centre in Salford.

Twenty-two-year-old Yvonne Morris, an electrical engineer P4 Grade with British Aerospace (Dynamics) Defence in Stevenage received the Mary George Memorial Prize—an additional award given to a young entrant showing particular promise as an Incorporated Engineer. Yvonne received a cheque for £ 250 and a silver salver.

Electronics – a key British industry

Britain's electronics business is today the fourth largest in the world after the USA, Japan and Germany, and by the year 2000 electronics will be the world's largest industry accounting for some ten per cent of mankind's GDP. The alliance of telecommunications, information technology, new digital electronics techniques, and multimedia communications networks allows a wide range of previously disparate industries to converge. The affiliation of of consumer electronics, cable TV and broadcasting, media groups, information services, publishing, software, banking, and retailing among others has been the result.

At the same time, the rapidly growing use of electronics in Britain and elsewhere gives the industry the status of a key industrial sector. Additionally, , electronics is an essential enabling technology that drives competitiveness, and even wealth creation, in the rest of UK industry, too. Between 1985 and 1990, the UK's share of electronics exports by the (G7) major industrialized countries increased from nine per cent to 11 per cent, the largest recorded rise.

Electronics has become a significant force and, with electrical engineering, is now the second largest industry in the UK. The industry's sales are worth £ 30 billion, and yearly investment runs at some £ 1 billion, alongside R&D's £ 2 billion. The workforce amounts to some 330,000.

As each year passes, electronics assumes more prominence in UK manufacturing. Value added increased by eight per cent yearly in the 1980s, and the industry increased its share of manufacturing output from five per cent in 1981 to seven per cent in 1990. Electronics in the UK is becoming less concentrated. Large enterprises employing more than 1000 now represent 55% of the sector from around 70% in 1980. Nearly 50% of electronics employment lies in the southeast, although Scotland and the West Midlands generate the highest value added per employee.

Capital equipment

Britain is particularly strong in telecommunications, data processing and software, alongside the provision of capital equipment for civil and defence purposes. Heavy investment in R&D demonstrates the industry's commitment to innovation with funding averaging six per cent of turnover.

Electronics' international nature is behind the UK's steady trend towards the development of international standards, which in turn creates the opportunities for the UK industry to exploit new markets. Hardware and software manufacturers are also meeting increasingly stringent security standards.

The UK industry knows its economic future depends upon its continuously improving its position in the global marketplace. The Federation of Electronics Industry (FEI) represents the industry where member companies are developing their response to the challenge and are pursuing policies to maintain their position among the world's electronics frontrunners. FEI, formed in January 1994 from the sector's two previous trade associations, brings UK-based telecommunications, information technology, computer services, defence electronics and office products, as well as electronic components under the same banner.

Federation of Electronics Industry, Russell Square House, 10-12 Russell Square, London, United Kingdom WC1B 5EE. Phone +44 171 331 2000. Fax +44 171 331 2040.

Differential GPS
for land use with RDS

By M. Ohsmann

The Global Positioning System, GPS, originally developed by the American Defence Department as a world-wide satellite-supported pin-point navigation system, is now widely used for civilian purposes. Receivers for civil purposes have been available and in use since the mid 1980s. These receivers are useful for a variety of purposes, for example, yachting, in-shore fishing,, fleet management of road transport, and surveying.

The system is based on a GPS station receiving the signals from several satellites. Assuming that the exact time (UTC—universal time co-ordinated) is known, the time of receipt of the various signals enables the distance to the different satellites to be computed (the satellite transmits UTC also). Since the positions of the satellites are contained in the transmitted signal, the position of the receiver can be established fairly accurately if signals from at least three satellites were received. The exact time can be calculated at the receiving station if the signal of a fourth satellite is also available. The position of the satellites is transmitted by the satellite. The position accuracy is less than a metre. More than 20 satellites ensure that at least six satellites can be received at any point on earth—see Fig.. 1.

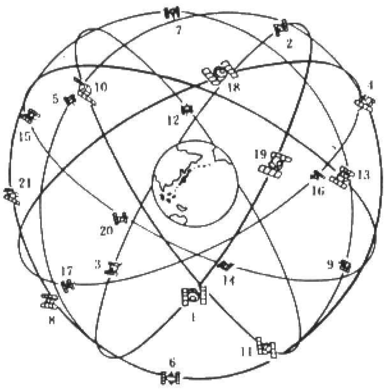


Fig. 1. The GPS is based on 21 NAVSTAR GPS satellites that circle the earth once every 12 hours at an altitude of roughly 20 000 km (12 000 miles). Their near-circular orbits are inclined to the terrestrial equator at 63°.

Degraded accuracy

Although the accuracy mentioned earlier is available to the military and special services user, it is not to the civilian user. This is called the standard positioning service with selective availability. It means that the civilian user cannot reckon an accuracy of better than 30–100 metres. This degradation arises from the fact that the satellite signals do not tell the civilian user its exact position, but a slightly different one. This causes a position error at the GPS receiver. Moreover, the generated error slowly changes.

Improved accuracy

The artificial degradation of the accuracy is countered as follows. A GPS receiver in an exactly known position serves as a reference. This reference receiver can determine with a fair degree of accuracy which satellite 'lies' to what extent. If it then makes these data known to other GPS receivers, these can improve the accuracy of their own estimated position greatly, since they know to what extent their position was degraded. This system of operation is known as Differential Global Positioning System—DGPS*. The data computed at the reference station are called the DGPS correction data. These have to be communicated to the GPS station by radio. A typical setup of this is shown in Fig. 2. There are various ways of doing this and these are described below.

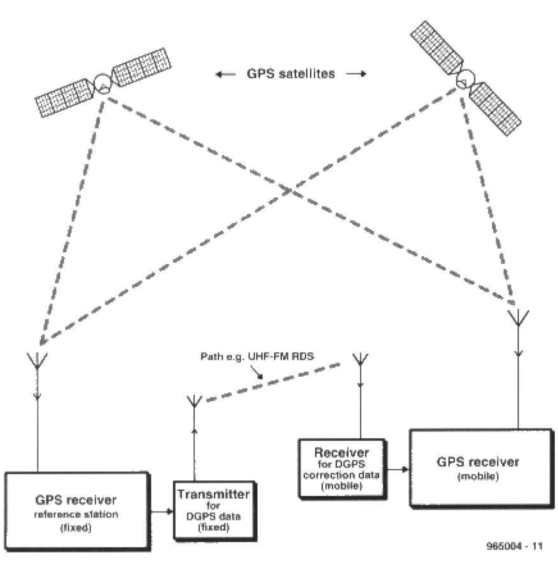


Fig. 2. The structure of a DGPS for pin-point navigation.

Local auxiliary transmitter

If the area in which the GPS accuracy is to be improved has narrow limits, such as an airfield or the lands of a farmer, a small, low-power local data transmitter can be used. Such a setup might cost a couple of thousand pounds, which makes it affordable only for professional applications. A number of airports are evaluating such system for future GPS supported blind landing procedures. The accuracy of DGPS in association with local auxiliary transmitters may be better than one metre.

Shortwave broadcasts with RDS

During the past ten years, the RDS system has come into wide use for the transmission of additional digital information on the broadcast signal. This system may also be used to transmit DGPS data (see 'PIC RDS decoder' in this issue). Several European station do so already. A typical arrangement is shown in Fig. 3. Figure. 2 shows that the position computed by a standard GPS station over a period of 24 hours drift by ±30 metres from the true position. With a DGPS station, the drift is lim-

Events in 1996

March
26–28: The **Nepcon Electronics** Exhibition at the NEC, Birmingham, UK.
28: A **Mobile Communications Workshop** at Gatwick Airport

April
The **Sixth International Conference on AC and DC transmission** will be held at the Institution of Electrical Engineers (IEE) in London from 29 April to 3 May 1996.

May
8–9: The **Electronics Scotland Exhibition** at Gleneagles, Scotland.
21–23: The **Internet World** Exhibition in London.

June
4–5: The **ICET 96** conference on electronics technologies in Brighton, UK.

July
16–18: The **Semicon/West 96** exhibition and conference in San Francisco.

August
The **CeBIT Home** Trade Fair will take place at Hanover, Germany on 28 August to 1 September.

September
2–8: The **Farnborough Airshow** at Farnborough, UK.

October
8–10: The **Euro-EMC** exhibition at Sandown, UK.
18–27: The **Connect 96** consumer electronics show at the NEC, Birmingham.

November
12–15: The **Electronics 96** exhibition in Munich, Germany.
26–28: The **Manufacturing Week** Exhibition at the NEC, Birmingham.

December
8–11: The **International Electronic Devices Meeting** in San Francisco.

In brief

International conference on Public Transport Electronic Systems

Electronics, computing and communications systems are being employed in ever greater degrees of sophistication. This international conference to be held at the Institution of Electrical Engineers in London on 21–22 May addresses the application of these system in all areas of passenger transport, either as on-board units or as part of the fixed transport infrastructure.

Embedded C51 Starter Systems from Equinox

Equinox Technologies has launched a range of Embedded C51 Starter Systems for the 8051 microcontroller family. These systems allow the user to develop embedded 8051 applications in C, using an integrated programmer/editor/compiler/source level debugger environment.
See page

Teletest 16 Emulator from Hitex

While much attention has been focused on the arrival of embedded versions of the 386 processor, chip manufacturers Intel, AMD and NEC continue to enhance the 16-bit members of the x86 family by adding embeddable-friendly features to the popular 186/188 and V-series processors, thus ensuring their continued use in control applications.
To support these devices, Hitex has introduced a range of emulation pods and cables for the popular T16 in-circuit emulator, offering existing users with an upgrade path in their designs.
See page

Microelectronics in Business

Under a new Euro-Practice Initiative, five MIB Support Centres have been appointed as Technology Transfer Nodes (TTNs). They are sited at the Universities of Paisley, Glamorgan, Hertfordshire and Bournemouth, and at the Bolton Institute. The nodes will provide a UK delivery mechanism to companies seeking support under the Euro-Practice 'First User Action' scheme (FUSE), designed to complement existing DTI programmes such as 'Microelectronics in Business'.

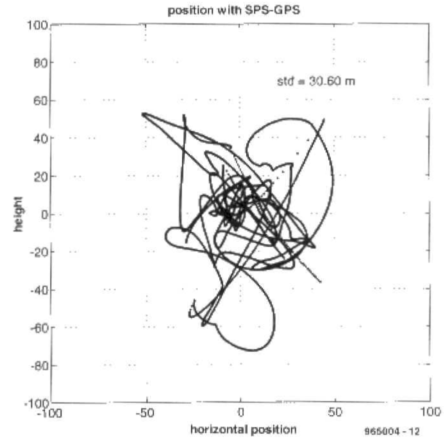


Fig. 3. Plotting a position with the GPS gives an accuracy of about 40 m.

ited to ±4 metres. This means that a DGPS station can determine the true position fairly accurately. This system can be used with reasonably priced receivers (DIY?); it does not need many transmitters to effectively cover a given area.

Long-wave broadcast via AMDS

A system—AMDS—has been developed for long-wave broadcasts on to which digital data (200 bit/s) inaudibly are superimposed. Its structure is similar to RDS and may also be used for the distribution of DGPS correction data. A number of European stations transmit these broadcasts on an experimental basis. Since the distances spanned by long-wave signals are very large, such stations can serve a very substantial area. The distance between the reference station and the local receiver may be as much as 1000 km (600 miles), but this may limit the achievable improvement in accuracy. In other words, the correction data lose some of their usefulness over long distances.

Long-wave services

Apart from long-wave broadcasting stations, there are private organizations that distribute DGPS over long-wave radio networks. In Europe, the German and Dutch Telecommunications Authorities are using the system at a number of sites and are evaluating its use at other locations.

In conclusion, it may be said that the DGPS, already in use for some time in the UK and USA, is now beginning to find widespread use in mainland Europe in a number of areas as well.

* Editor's note. This system has been in maritime use since the late 1980s.

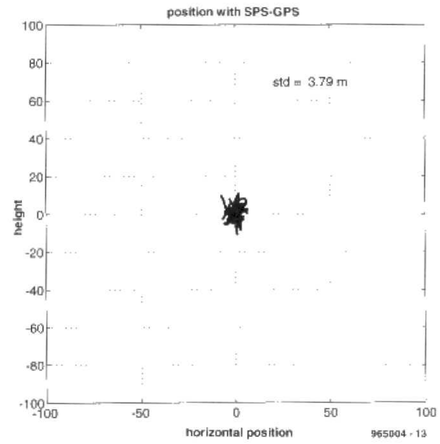


Fig. 4. Plotting a position with DGPS via RDS gives an accuracy of about 4 m.

Physics World - High Technology in action

Thousands of scientists from the Uk and overseas will be in Telford in April for the annual Physics World Exhibition, the most important UK event for physics related technologies.

Run in conjunction with the Institute of Physics Annual Congress, the exhibition (Telford International Centre, 23–25 April, 1996) enables scientists to evaluate, compare and place orders for the products and allied services displayed and demonstrated by over a hundred leading scientific suppliers. Exhibitors will show a wide range of high technology solutions, relating particularly to vacuum and semiconductor processing, nuclear technology, environmental physics, spectometry, microscopy, optics and lasers.

The Institute of Physics Annual Congress, alongside which the exhibition runs, aims to increase recognition of the importance and relevance of physics in all aspects of our daily, personal and professional lives and as such is of interest not only to physicists, but scientists and engineers in a wide variety of sectors and disciplines. The programme of scientific conferences will cover topics as wide-ranging as recent developments in silicon sensors, the physics of musical instruments and the latest physics R&D.

Full information on all aspects of Physics World Exhibition is available from The Institute of Physics, 47 Belgrave Square, London SW1X 8QX. Telephone +44 171 235 6111. Fax +44 171 259 6002. e-mail IOP@ULCC.AC.UK.

UK telecoms pointing the way to the future

The liberalization of the telecommunications in the UK has been a spur to both technical and commercial developments. Furthermore, the country is moving from a duopoly to an environment where are many operators.

However, while virtually everyone in Britain has benefited from reduced charges and the rapid introduction of advanced services, the most visible changes have occurred in mobile communications. One of the results has been that the battle, originally for the phone on the desk or in the home, is equally for the phone-in-the-hand. In fact, fixed and mobile are converging with the result that, ultimately, users may have the universal personal phone.

With six networks from four rival operators, competition in mobile communications in the UK is exceedingly strong. The two cellular operators, Vodafone and Cellnet, which both launched their analogue networks in 1985, now also offer GSM—the pan-European digital service. In addition, there are two PCN networks.

Even before the PCN networks were launched, the cellular operators introduced low-user tariffs where, in return for lower monthly rentals, users paid a higher charge per minute usage. This, coupled with the fact that subsidized handsets could be bought for less than £ 5, opened the market to the consumer in addition to the business user. While the low initial charge is attractive, the operators are faced with a high level of 'churn' as customers cancel their contracts as soon as possible once they realize the true level of ongoing costs. Hence, it is important for operators to increase the number of new customers signing on while, at the same time, containing the number of cancellations.

Attractive proposition

With the cellular networks already covering 98% of the population, the emergent PCNs needed and attractive sales proposition—especially in view of the fact that their handsets were not being heavily subsidized and thus cost a minimum of £ 150—to counter their lack of geographic coverage. When one-2-one launched its service in the Greater London area (roughly 20% of the UK population), it targeted the consumer market by offering free evenings and weekend local calls. At the launch, Lord Young, chairman of Mercury' s parent company Cable & Wireless, stated that the service was not intended to compete with the existing mobile networks, but with the fixed telephone network. This is obviously an ambitious goal.

However, while one-2-one concentrated its efforts in the London area, Hutchison Telecom's Orange is aiming to develop a national network as rapidly as possible ad already claims to be available to 70% of the population.

Thus, it can be seen that there are already real choices for UK users.

Furthermore, as one-2-one offers free evening and weekend local calls to customers of its residential (as distinct from business) tariff, the effect is that these users tend to identify their one-2-one phone as meeting all their communications needs—both at home and on the move. This position is strengthened by its using the Short Message Service as a means of indicating that a voice message is waiting. Voice messaging can be seen as providing the user with a built-in answering machine.

Business tool

On the other hand, Orange's strategy is to make its service a more complete business tool. Its SMS can be used to send text messages between phones—just like a message pager, but with a confirmation that the message has been received. However, one service that it has had on trial for some months is a form of cordless PABX, whereby Orange phones can be integrated within an organization's telephone system. This can be seen as the ultimate form of cordless PABX in that 'extensions' can be anywhere within the Orange service area. This is getting close to the ideal universal mobile phone.

While mobile communications has enjoyed a high profile, there have also been major changes in the UK's fixed network stemming from the 1991 Duopoly Review. This opened the door for new operators to provide fixed link services. The most important new entrant is Energis, owned by a consortium of the country's electricity distribution companies. It has the benefit of being able to employ the National Grid power network to carry the fibres of its 2.54 Gbit s^{-1} Synchronous Digital Hierarchy (SDH) backbone optical fibres, thus reducing both the cost and time in network deployment. In Fact, Gordon Owen, Energis's chairman, claims that this results in costs being only about a quarter of those incurred by Mercury when it rolled out its network.

Energis is offering an indirect service, where residential and business customers gain access via their existing BT lines. In addition, it works in conjunction with regional operators. While Mercury, Energis and other new operators offer competitive prices, their margins are currently being eroded. This is because, while there is low inflation, BT is reducing its own prices to remain within the overall price formula set by the Office of Telecommunications (Oftel) of RPI (Retail Price Index)—7.5% for the basket of BT's main prices.

But this is not all. Within the European Union, telecommunications services and infrastructure are set to be fully liberalized by 1 January 1998. BT and the German industrial group VIAG have announced that they have formed a strategic alliance to take advantage of the new regime. Moreover, AT&T has been granted a telecommunications licence in the UK. Thus, as the world of telecommnications gets smaller, the importance of the UK gets greater.

In passing ...

We have reached the stage where it is difficult to think of something that can work without electronics. Even a simple and straightforward machine like a bicycle has not been able to stem the tide.

Many people on city bikes, mountain bikes and standard bikes pedal around without paying the slightest attention to the environment, but looking intently at a little box of electronics fitted to the handlebars. This bicycle computer faithfully registers distance travelled, time, speed, pedalling rate, and, if so desired, your heartbeat. A true example of modern technical ingenuity!

I used to have one on my bike—used to, but not any more; I could not stand it. The problem with these cipher machines is that they are ruthless.

You are cycling along happily and see that you have done so many miles already; this pleases you. Press the button and you see the time elapsed since you started. Fine! Press the button once again and you see what your speed is: pedal a bit harder and the speed goes up to 18 MPH. But then: trouble—you press the button once more and see to your horror that your average speed is only 14.5 MPH. How is that possible, when you have been pedalling much faster than that?

Gone is the exhilaration. The remainder of your trip is spent in looking in frustration at the display to make sure that your average speed goes up. And so you come home exhausted—at an average speed of 15 MPH!

When my unequal struggle with the computer had reached the stage where my well-being and appetite began to suffer, my wife took me aside and spoke to me firmly. The outcome of it was that I removed the computer from my bike and now cycle about again happily unaware of things like average speed and distance covered.

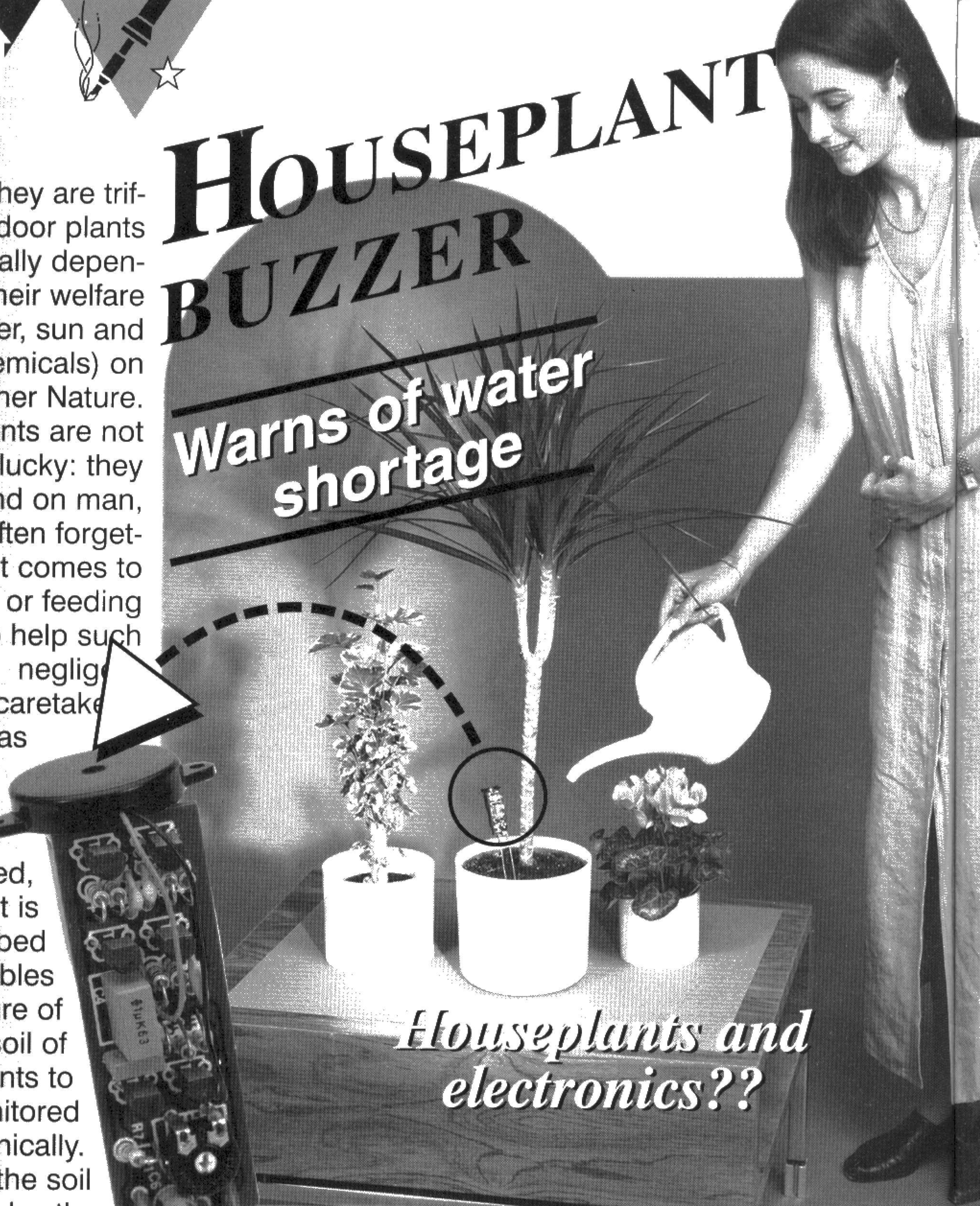
What's more, I feel better and my appetite is back!

HOUSEPLANT BUZZER

Warns of water shortage

Unless they are triffids*, outdoor plants are totally dependent for their welfare (water, sun and chemicals) on Mother Nature. Houseplants are not that lucky: they depend on man, who is often forgetful when it comes to watering or feeding them. To help such negligent owners/caretakers, at least as far as watering is concerned, a circuit is described that enables the moisture of the soil of houseplants to be monitored electronically. When the soil gets too dry, the monitor emits a series of squeaks to warn the owner or caretaker to add water.

by P. Kersemakers



"Say it with flowers" is a well-known slogan and it is a fact that (most) people like flowers and plants in general. Of course, plants are of tremendous importance to animal life in providing food and oxygen. But, where many outdoor plants have great nutrimental or photosynthetic value, houseplants are normally kept for their decorative effect. This decorative effect soon becomes blemished, however, when the plant is not watered regularly.

To help the many people who forget to look after their houseplants routinely, the circuit described here

* *The Day of the Triffids* by John Wyndham (1951) describes a race of monstrous, stinging plants, mobile and rapidly multiplying, of invasive habit and malign intent. The book was made into a successful film a few years later.

will sound a warning when the plant soil becomes too dry and will continue to do so until water has been added to the dry(ing) soil. Owing to the low current drain, the monitor can operate from a single dry battery for up to a year.

Principle

The operation of the monitor depends on the property of water to conduct when it contains chemicals, such as alkalines or acids (found in abundance in good potplant soil and drinking water). This means that moist soil is a fairly good electric conductor. When the soil dries, it becomes less and less conductive.

Figure 1 shows the principle of the monitor. The electrical resistance, *R*, of the soil is measured by a pair of sharp pointed probes, E_1 and E_2, which are pushed into the soil. The resistance is continually monitored by a simple circuit. When the soil gets (too) dry, this circuit actuates a piezo-electric buzzer, Bz. Since the required moisture varies from plant to plant, a preset, P, is added to set the minimum allowable moisture.

The reliability of the circuit depends almost entirely on that of the probes. Were these to carry even only a tiny direct current, in the moist conditions in which they are used, they would soon be subject to rapid oxidation or electrochemical destruction. That is, depending on the direction of the direct current, one of the probes would soon be enveloped in a film of oxide, while the other would be (partly) dissolved. This electrolysis is negated by the use of an alternating current instead of a direct current.

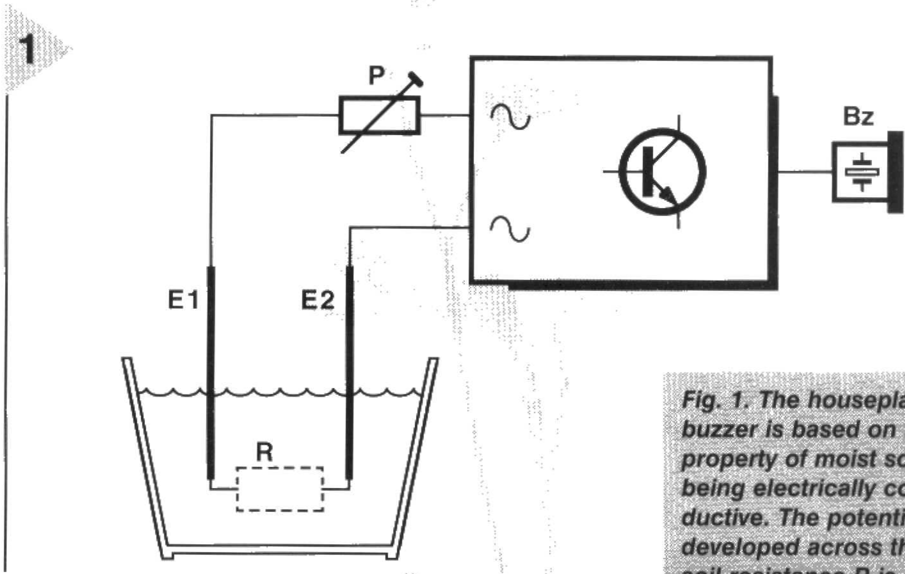


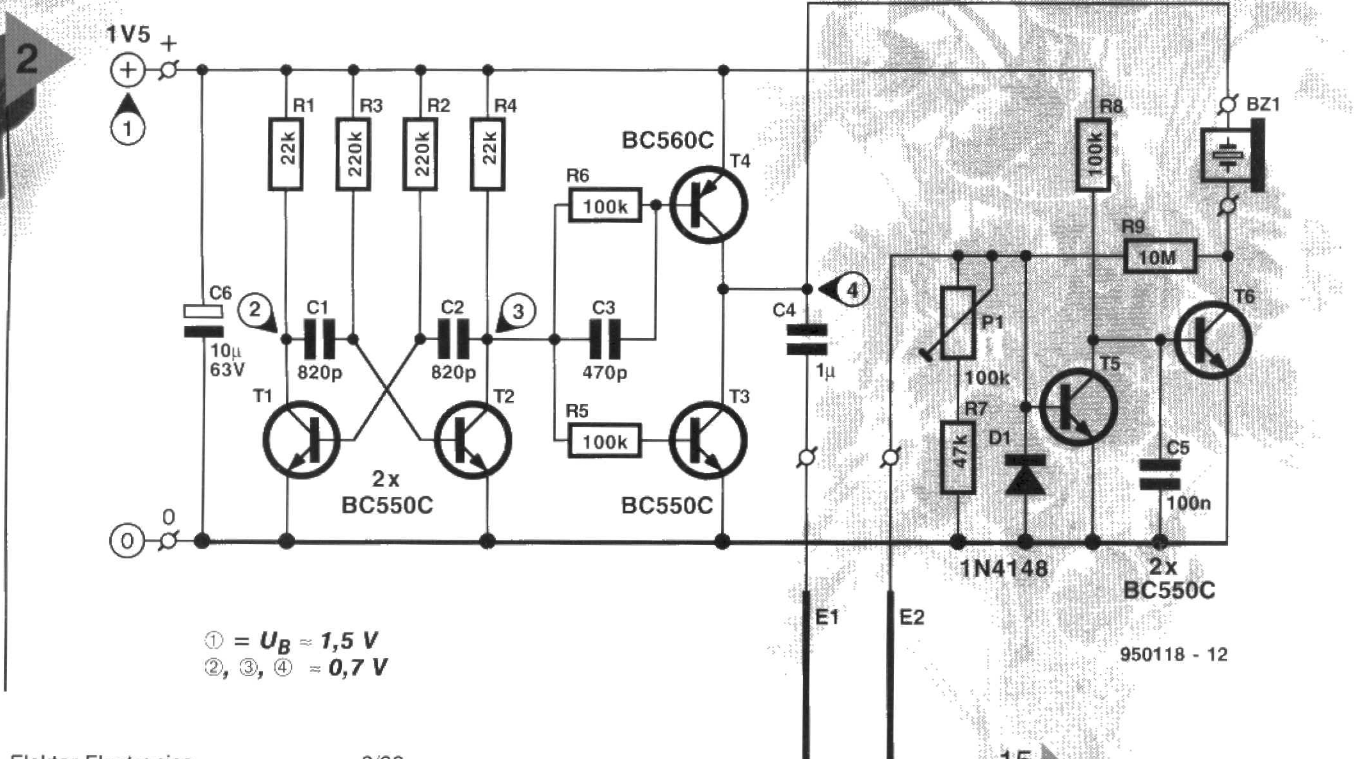
Fig. 1. The houseplant buzzer is based on the property of moist soil being electrically conductive. The potential developed across the soil resistance R is measured via probes E1 and E2. If the soil is dry(ish) (R = high), a buzzer sounds.

Design

Since nobody wants an unsightly piece of electronic hardware sticking conspicuously into their decorative houseplant pots the design has been aimed at making the monitor as tiny as possible. The resulting printed-circuit board is only slightly larger than the HP7 dry battery that powers it.

The low e.m.f. of an HP7 battery (1.5 V) puts certain restrictions on the electrical design. Bear in mind that silicon transistors need about 0.7 V to conduct, which leaves precious little of the battery voltage for driving them. This is, by the way, the reason that the circuit—see Fig. 2— is based on discrete transistors. Integrated circuits (ICS) normally need a higher supply voltage.

Fig. 2. The circuit is based on a rectangular-wave generator, T1-T2, and current-sensitive switch T5-T6. The generator provides the current with which the conductivity of the soil is measured, and the current to actuate the buzzer.



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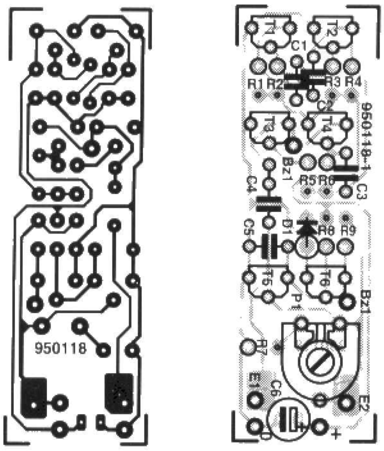


Fig. 3. The printed-circuit board for the houseplant buzzer has been kept as small as feasible to ensure that the finished product does not detract from the decorativeness of the houseplant.

The circuit based on transistors T_1 and T_2 forms a rectangular-wave generator. The values of resistors R_2 and R_3 and of capacitors C_1 and C_2 ensure that the generator produces a rectangular voltage at a frequency of about 3 kHz.

The generator fulfils two functions: it provides the alternating current for the probes and the signal for actuating the buzzer.

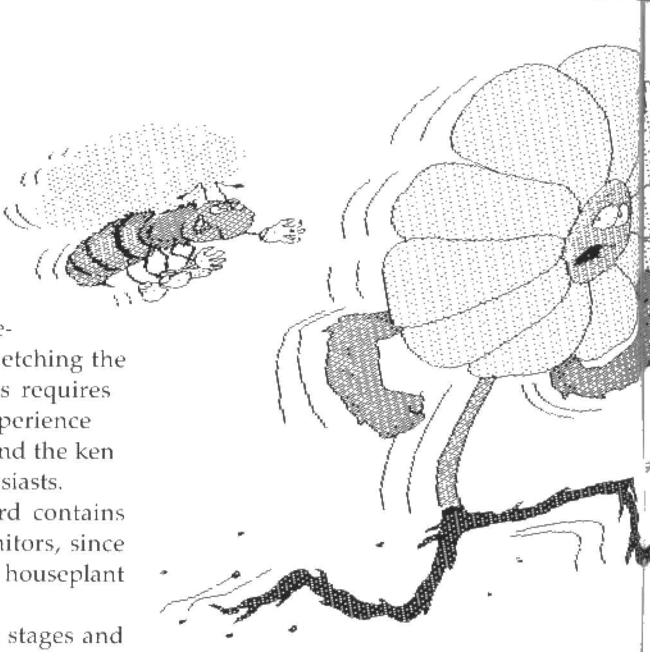
Current amplifiers T_3 and T_4 form a load-compensating network for the generator.

When the moisture of the relevant soil is correct, the generator signal, amplified by T_3-T_4, is applied to the probes, E_1 and E_2, via capacitor C_4. This capacitor prevents any direct voltage from reaching the probes. The conducting soil between the probes closes the measuring-current loop, so that this current reaches electronic switch T_5-T_6. This switch is current-sensitive; when the current is above a certain level, T_6 is cut off, so that the buzzer can not be actuated.

When the soil becomes dry, the measuring current becomes smaller, so that, depending on the setting of P_1, switch T_5-T_6 is enabled. This means that T_6 conducts and the buzzer is actuated to emit a 3 kHz tone.

CONSTRUCTION

Since the printed-circuit board (see **Fig. 3**) is small, soldering has to be carried out with great care. The board is available ready made (see p.70), but it may also be made in the home workshop. This entails making a 1:1 photocopy of the track layout on to film, transposing the film copy on to a (positive-sensitive) PC board, and etching the superfluous copper. This requires patience (lots) and experience (some), but it is not beyond the ken of most electronics enthusiasts.



The ready-made board contains sub-boards for four monitors, since generally more than one houseplant needs monitoring.

Populate the board in stages and check the work after completing each stage.

The work is begun by soldering resistors R_1–R_4, followed by capacitors C_1, C_2 and C_6, and then transistors T_1 and T_2 in their relevant positions. Note that, to save space, the resistors are mounted upright. Next, solder the battery-holder leads to the board.

Insert an HP7 battery into the holder. Use a multimeter, set to the 2 V d.c. range, and check that the voltages at the test points indicated in **Fig. 4** (with respect to earth, that is, the –ve terminal of the battery) are: ①: battery voltage, U_b; ②, ③, ④: $U_b/2$. If the potentials at 2 and 3 (collectors of T_1 and T_2 respectively) are about half the battery voltage, it may be assumed that the generator functions correctly. If these potentials are much smaller than $U_b/2$, the resistors are placed incorrectly or their value is wrong. If the potential is much higher than $U_b/2$, there is something awry with the transistors (wrongly connected or incorrect type).

If the potentials are as stated, remove the battery from the holder, solder R_5, R_6, C_3, T_3 and T_4 into place,

Squeaking crystals

The piezo-electric effect occurs when certain materials (crystals) are subjected to mechanical stress. Electrical polarization is then set up in the crystal, whereupon the faces of the crystal become electrically charged. The polarity of the charge reverses if the compression is changed to tension. Conversely, an electric field applied across the material causes it to contract or expand according to the sign of the electric field.

The effect is observed in all ferroelectric crystals and in all ferroelectric crystals that are asymmetric and have one or more polar axes.

The effect is important because it couples electrical and mechanical energy and thus has many applications for electromechanical transducers. Piezoelectric crystals are used to provide frequency standards and in piezoelectric oscillators.

Figure (a) shows the principle of a domestic application: a lighter for gas fires. The hammer represents the mechanical force acting on the piezoelectric material. The voltage resulting from the distortion of the material is indicated by the meter.

Figure (b) shows the change of shape of a piezoelectric material when an electric potential is applied to it. When the electric potential is an alternating one, produced for instance by the rapid opening and closing of a switch as in Fig. (c), the material will vibrate in rhythm with the rate of opening and closing of the switch. If this rate lies in the frequency range 20–20000 Hz, the air displaced by the vibrating material will be audible. This is the principle of operation of the buzzer used in the houseplant moisture monitor.

and reinsert the battery into the holder. With the multimeter set as before, check that the potential at test point 4 (collectors T_3, T_4) is $U_b/2$. When the multimeter is momentarily replaced by the buzzer, this should emit a 3 kHz tone. If no tone is heard, it may be that its frequency is much too low or too high; this may be caused by incorrect values of C_1, C_2.

When all is correct, remove the battery from the holder, solder the remaining components into place and connect the buzzer provisionally. Set the multimeter to the 1 mA d.c. range and connect it in series with one of the battery holder leads. Reinsert the battery into the holder and check that the current drain is 0.1–0.2 mA. If it is appreciably different, check the value of all resistors.

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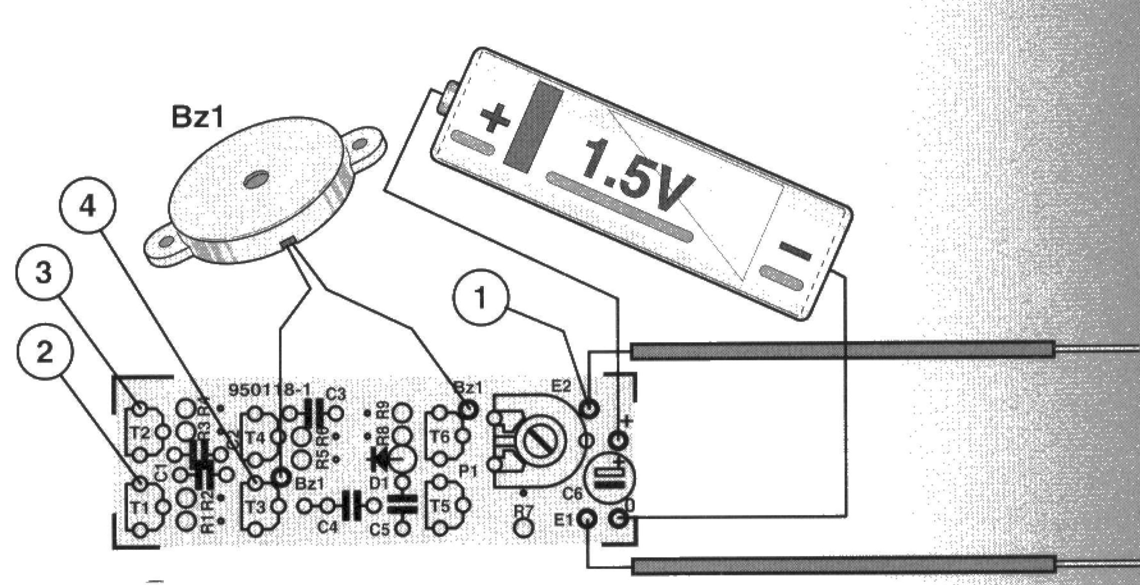


① = U_B

②③④ $^1/_2$ U_B

Fig. 4. Various test points on the pcb. See text for values at these points.

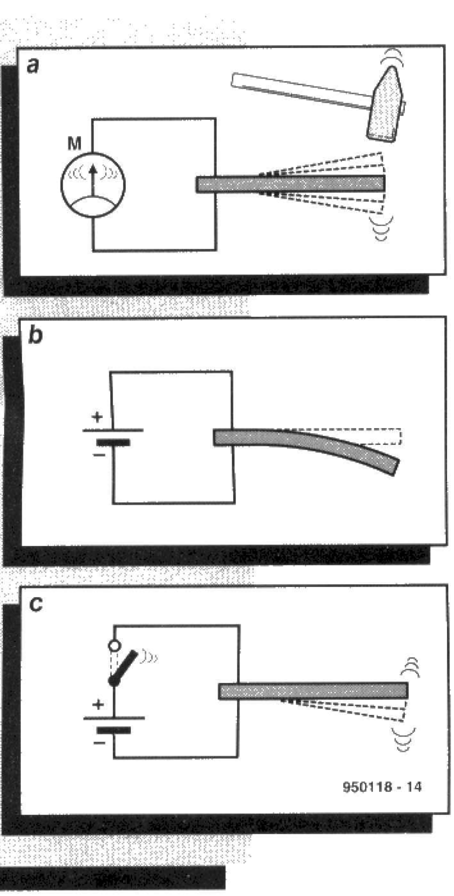
When all is well, fix the battery holder on to the track side of the board with double-sided adhesive tape (available from most stationery and DIY shops). The advantage of this tape is that the holder can be removed at a later date if necessary. Fix the back of the buzzer to the battery holder (at the end opposite T_1, T_2) with superglue.

The probes consist of 15 cm lengths of 1 mm thick insulated copper wire, from each of which 2–3 mm insulation is removed at one end and 4 cm at the other end. The 2–3 mm bare ends are soldered to the board. The 4 cm bare ends are tinned to prevent any oxidation. Make sure that the probes are straight and equidistant (12 mm) from each other.

Usage

After the battery has been inserted into the holder, push the monitor upright into the soil. Make sure that the bare probe ends are fully in the soil, but take care that there is sufficient space between the board and the soil to prevent the board getting wet when the plant is being watered. Alternatively, bend the probes to allow the monitor to hang over the rim of the pot on the outside.

Normally, the monitor is pushed into the soil only near the time when watering of the plant is due (a matter of experience). With the probes in dry(ish) soil (as relevant to the plant), set P_1 to a position where the buzzer is silent, and then adjust it till the buzzer just operates. Sprinkle water on to the soil (away from the monitor), wait a few minutes for it to get well into the soil, and check that the buzzer ceases to work. If necessary, readjust P_1 with the probes inserted into a different pot. (950118)



Components list

Resistors:
R1, R4 = 22 kΩ
R2, R3 = 220 kΩ
R5, R6, R8 = 100 kΩ
R7 = 47 kΩ
R9 = 10 MΩ
P1 = 100 kΩ preset

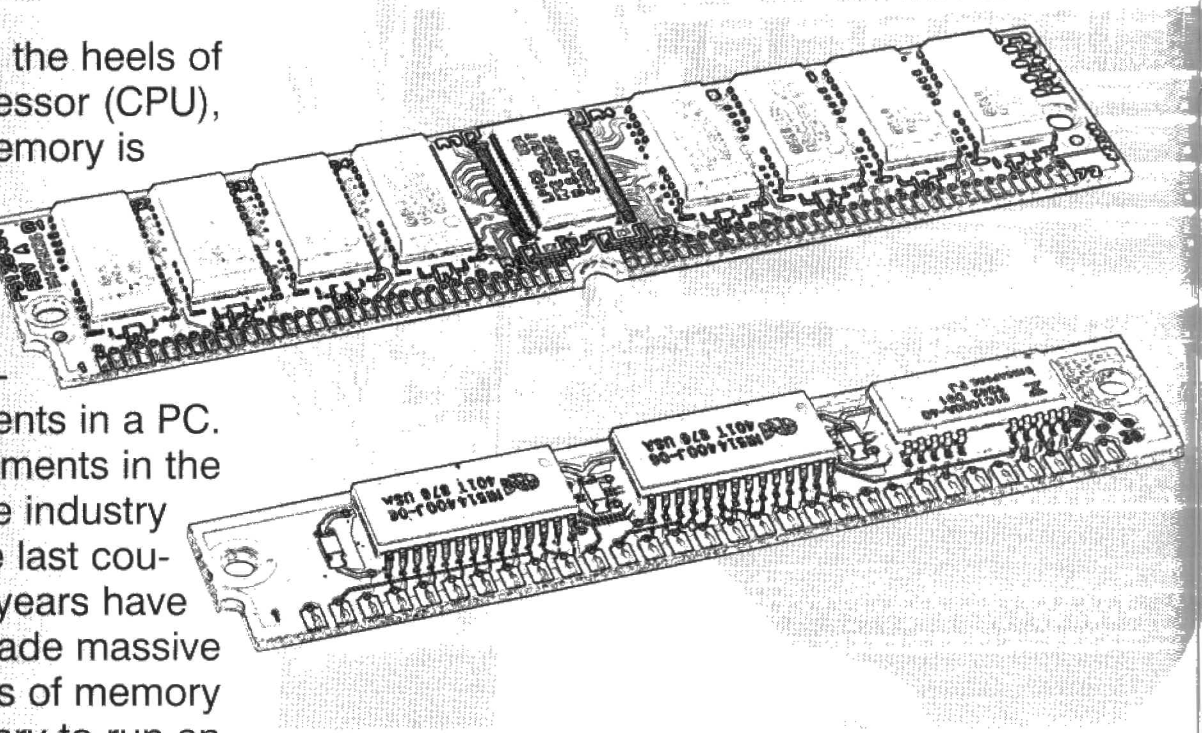
Capacitors:
C1, C2 = 820 pF
C3 = 470 pF
C4 = 1 μF
C5 = 100 nF
C6 = 10 μF, 63 V, radial

Semiconductors:
D1 = 1N4148
T1–T3, T5, T6 = BC550C
T4 = BC560C

Semiconductors:
D1 = piezo-electric buzzer, 1.5 V
1 off HP7 (AA, R6) dry battery
1 off holder with leads for battery
1 mm thick insulated copper wire for probes (see text)
PCB Order no 950118-1 (p. 70).

FOCUS ON: PC MEMORY CHIPS

By our editorial staff



Close on the heels of the processor (CPU), the memory is one of the most important components in a PC. Developments in the software industry over the last couple of years have made massive amounts of memory necessary to run an operating system like MS-Windows. Today, there are so many different types of memory available that it is no longer easy to know exactly which type to use for a particular application. An introductory overview is therefore presented in this article.

megabytes on square centimetres

SRAMs, DRAMs, EDO RAMs, SIMMs, SIPPs ..., there is a such bewildering number of memory options for the computer that it is hard to keep them apart and, more importantly, to select the right type if you want to extend the memory in your computer.

In principle, it is all very simple. Currently, two types of memory are available: static RAM (SRAM) and dynamic RAM (DRAM). RAM stands for *random access memory*. In a static RAM, each memory cell consists of a flipflop (comprising a few semiconductors) which is at one of two logic states, and so capable of 'remembering' a value. The dynamic RAM has a much simpler construction: a capacitor is charged or discharged by a field-effect transistor (FET) or an ordinary transistor. The major disadvantage of this type of memory is, however, that the memory contents has to be refreshed frequently (every few milliseconds) because the charge contained in the capacitor disappears slowly because of leakage. This leakage is significant because capacitors in a DRAM have a capacitance of less than 0.1 pF. This problem calls for a more complex type of drive. Because charging and discharging a capacitor takes more time than making a semiconductor switch on or off, static memories are much faster than dynamic ones. The latest SRAMs boast access times of 10 to 20 ns (nanoseconds), while values of 60 to 70 ns are common with state-of-the-art DRAMs.

Because of the more complex structure of the SRAM, this device is typically larger and more expensive than its dynamic counterpart. That's why the mass memories in today's computers consist mainly of DRAM. SRAMs are only used for fast intermediate memories (cache).

Second-level cache

Since the introduction of the 80386 processor, PC motherboards have a certain amount of fast cache memory that forms a buffer between the fast

processor and the much slower (but relatively expensive) DRAM memory. Cache memory these days comes in two variants: asynchronous and synchronous SRAM. With asynchronous SRAM, the processor has to wait for the associated data to appear at the outputs after it applies an address. With synchronous SRAM, an address is supplied, and then the data also appears after some time. However, the SRAM then immediately sends the data at the next three locations, without actually requiring new addresses. This trick results in faster timing.

The latest in cache memory is the *pipelined burst cache RAM*, which is based on the principle of the synchronous SRAM. The pipelined version however has an extra buffer ('latch') at its outputs, which enables a new address to be supplied while data are still being read from the outputs. This allows access times of between 4 and 8 ns to be achieved, so that even the fastest Pentiums can process cache memory data without wait loops.

SRAMs come in many different physical shapes and sizes. Until recently, SRAMs used to be housed in ordinary DIL cases. Nowadays they are often implemented as surface-mounted devices (SMDs), and are soldered directly on to the board. The latest development is the cache module, which is plugged into a socket on the motherboard. Such a module simplifies exchanging the cache memory considerably.

Millions of capacitors

As already mentioned, the large user memory in your PC consists of dynamic RAMs. During the course of computer history, the capacity of DRAMs has grown steadily. Way back in 1970, the first 1-Kbit DRAM appeared on the market. Today, 256-Mbit chips are being developed and tested in semiconductor laboratories. With DRAMs, too, the physical appearance has changed considerably. Whereas the first computers had lots of memory chips in DIL (dual-in-line) plastic or ceramic cases, today's computers contain almost exclusively SMDs.

To make changing the memory configuration on the motherboard a little easier for the user, modules have been developed. These are small printed-circuit boards which contain a number of memory chips. Initially, there were two types of module: the SIPP and the SIMM. The difference is easy to see: a SIPP has connecting pins, while a SIMM has connecting copper pads (contact fingers) on the board. Meanwhile, SIPPs seem to have died out, and today's PC motherboards allow only SIMMs to be fitted. SIPP-to-SIMM adaptors are still available, however.

Originally, SIPPs and SIMMs were invariably 30-pin modules. Today, however, an increasing number of SIMMs is of the 72-pin type, which is identified as the 'PS/2 SIMM'. The 72-pin SIMM and its 30-pin predecessor have different memory structures, as will be seen further on in this article.

Memory organisation in a PC

Since the introduction of the Intel 8086 CPU, the bus width of processors has shown a steady increase. Limiting ourselves to the CPU generations which are important in this day and age, it is seen that the 80386 and 80486 feature an external bus width of 32 bits, and the Pentium, one of 64 bits. Add to

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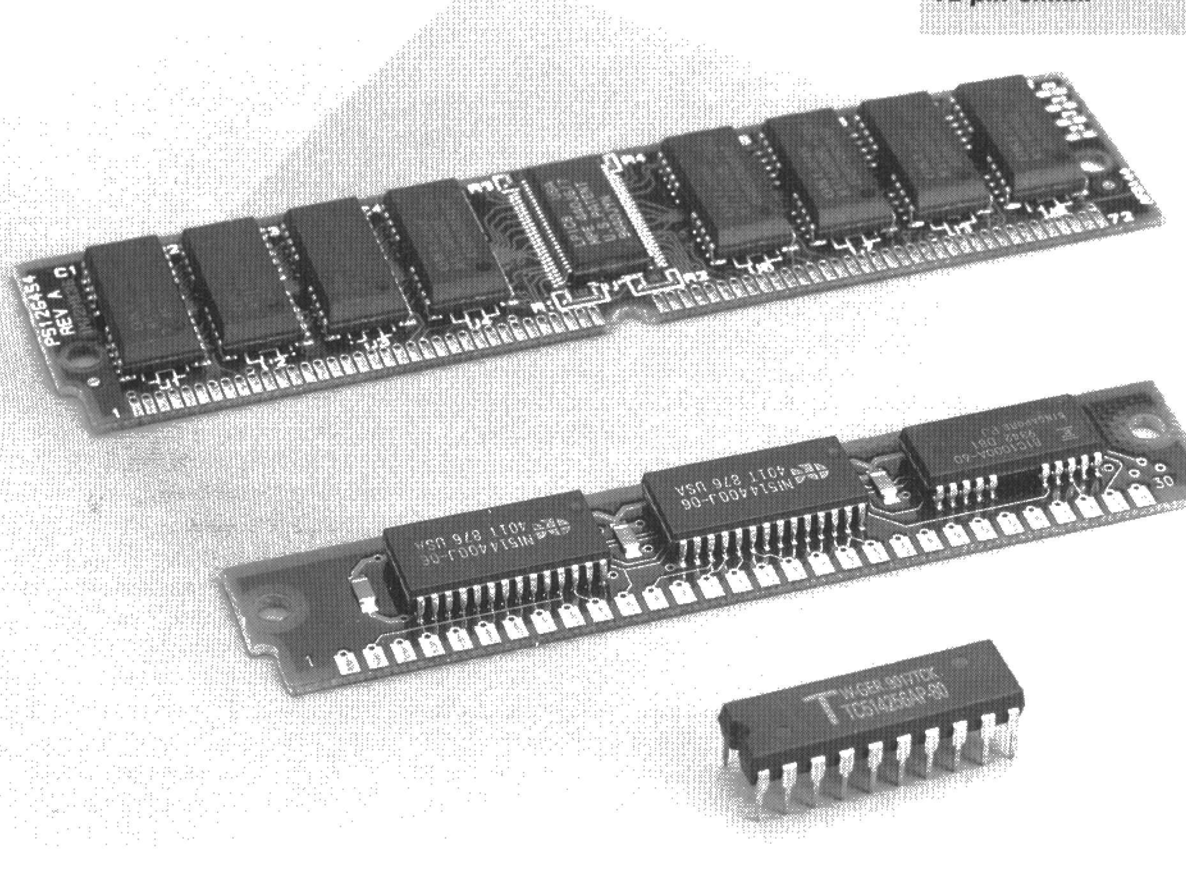

Fig. 1. Three different packages used for memory ICs: the good old DIL case as you probably know it from many other ICs; the 30-pin SIMM and the 72-pin SIMM.

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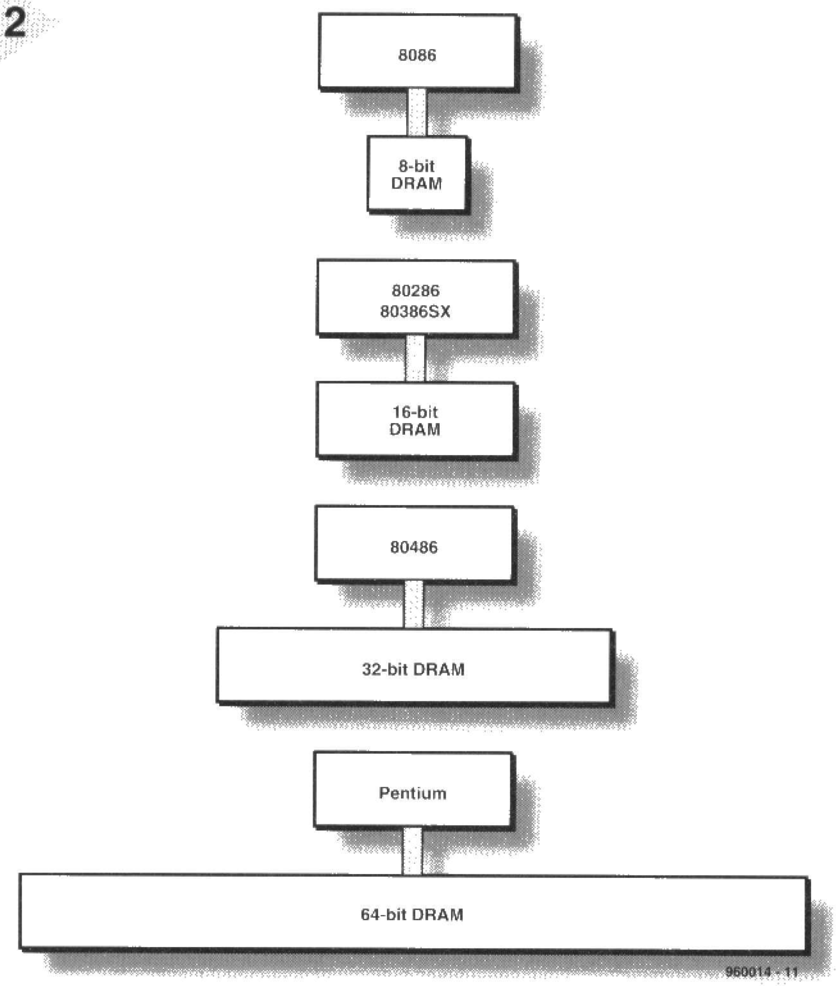

Fig. 2. The processor bus width also determines the logic width (in bits) of the memory banks. This is an important fact to keep in mind when you start thinking about extending the memory of your PC.

that the fact that an ordinary SIMM has a width of eight bits (sometimes nine if a parity bit is available), and a PS/2 SIMM, a width of 32 bits, and you will have no problems understanding why a PC motherboard must contain a certain number of memory modules. Such a group of modules with a total width equal to the CPU's external bus width is called a *bank*.

An 80386 or 80486-based computer has to be fitted with at least four SIMMs to allow the full bus width of 32 bits to be addressed in one operation. If you want to increase the memory of such a PC, that is only possible by adding at least four SIMMs. However, if PS/2 SIMMs are used, it is possible to work with one module at a time, because the module has a width of 32 bits. This is illustrated diagrammatically in **Fig. 2**. With a Pentium, the memory bus width should be 64 bits, so that you are forced to work with multiples of two PS/2 SIMMs (Pentium motherboards usually contain 72-pin memory slots only)

DRAM TYPES

Until recently, there was just one (generic) type of DRAM for computer use. The only specification that mattered in the choice of this device was the access time. This specification is

RAM Doublers

Memory requirements for PCs have increased dramatically since the arrival of MS-Windows 3.1, and even more so when Windows 95 was released. Eight megabytes seems to be the minimum amount of memory a PC should have to be able to use these operating systems at all. But memory is expensive, however, and some software houses recognized the market potential of a product which enables the amount of memory to be increased artificially. These programs are generally referred to as RAM doublers.

How do they work?

To begin with, a RAM doubler provides much better resource management. Useful as that may be with Windows 3.1, it is not normally necessary with Windows 95. Secondly, these programs do exactly what their (generic) name implies: they increase the amount of memory available. Use it made of the fact that Windows uses a swap file. Basically, that is a file on the hard disk which is used to store data if it does not fit in the user memory any more. Because a hard disk is much slower than a memory, the use of a swap file tends to slow the computer down. Most RAM doubler software compresses data before writing it to the hard disk, so that less space is taken up (the process is similar to the file compression techniques used by pack/unpack programs such as PKZIP or ARJ). Good! On the down side, however, compressing and decompressing data is a software overhead which takes time, and requires a dedicated buffer area to be reserved in the user memory. The net profit is, well, marginal, if we are to believe the test results published in various computer magazines. Here, too, the rule is: nothing beats real RAMs. None the less, those of you struggling with Windows 3.1 or a small hard disk may like the results of programs such as SoftRAM, RAM Doubler or MagnaRAM. Most of these programs may be obtained at prices of 25-odd pounds.

usually printed on the device as a suffix to the type number. For most 80386 and 80486 based machines, 60 ns or 70 ns is a good choice. With modern PCs, however, the external bus clock is so high that a couple of wait states have to be 'thrown in', not for amusement, but to allow data to be processed reliably even if 60-ns DRAMs are used (which are currently the fastest types around).

Because DRAMs faster than 60 ns are still difficult to produce in volume quantities, the manufacturers have come up with a couple of tricks to make their DRAMs faster, at least as far as a number of tasks are concerned. Today's magic word is *EDO-RAM*. The abbreviation stands for *extended data out*. A special output register enables data to remain available longer at the output of the RAM. This allows a new address to be supplied while the data with the previous address is still being read. In practice, this approach offers a speed increase of between 10 and 20 per cent as far as data exchange is concerned between the CPU and the memory.

EDO-RAM is normally a little more expensive than ordinary DRAM. The price difference is, however, expected to disappear before long. The control electronics on the motherboard must be capable of driving EDO-RAM. Consequently, you can't normally mix EDO-RAM and regular RAM on a PC motherboard.

In spite of its higher (apparent) speed, EDO-RAM is no real substitute for a second-level cache. The latter remains essential for fast intermediate processing of memory data. Meanwhile, our highly esteemed memory chip manufacturers have come up with yet other variants like *burst-CAS DRAM*, *synchronous DRAM*, *RAMbus DRAM* and *multibank DRAM*. None of these is, however, ready for wide application in computers.

About the parity bit

Since the introduction of the first IBM PC-XT, all 'compatibles' (clones) have used a memory which contains a parity bit. The parity bit is an extra bit that represents the checksum of the other eight bits. It allows the CPU to check the integrity of the data contained in the memory.

Unfortunately, memory ICs can develop so-called *soft errors*. These errors are caused by alpha parts from radioactive Kalium$_{40}$ which is present inside the IC enclosure. In the mean time, the production of the relevant materials is under much stricter control, and the density of the chips has increased appreciably. These two facts have reduced the occurrence of a soft error to about once in ten years, assuming that a modern system is used in a normal way. The risk of a soft error occurring is considered so small that you may reasonably question the need for a parity bit. Moderns SIMMs, whether 30 or 72-pin types, may be purchased with or without a parity bit, or with a simulated one. Incidentally, there are many PC motherboards around these days that do not use the parity bit at all. If that is the case, it makes no sense to fit memory modules with a parity bit. In any case, buying memory modules with a parity bit seems unnecessary if you have a fairly recent motherboard.

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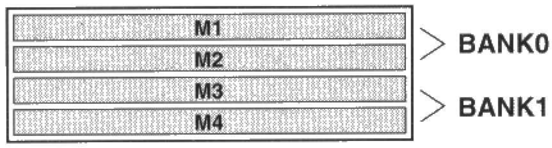

M1,M2(BANK0)	M3,M4(BANK1)	Total Size
1M x 32 (4MB)	Empty	8MB
1M x 32 (4MB)	1M x 32 (4MB)	16MB
1M x 32 (4MB)	2M x 32 (8MB)	24MB
1M x 32 (4MB)	4M x 32 (16MB)	40MB
1M x 32 (4MB)	8M x 32 (32MB)	72MB
2M x 32 (8MB)	Empty	16MB
2M x 32 (8MB)	1M x 32 (4MB)	24MB
2M x 32 (8MB)	2M x 32 (8MB)	32MB
2M x 32 (8MB)	4M x 32 (16MB)	48MB
2M x 32 (8MB)	8M x 32 (32MB)	80MB
4M x 32 (16MB)	Empty	32MB
4M x 32 (16MB)	1M x 32 (4MB)	40MB
4M x 32 (16MB)	2M x 32 (8MB)	48MB
4M x 32 (16MB)	4M x 32 (16MB)	64MB
4M x 32 (16MB)	8M x 32 (32MB)	96MB
8M x 32 (32MB)	Empty	64MB
8M x 32 (32MB)	1M x 32 (4MB)	72MB
8M x 32 (32MB)	2M x 32 (8MB)	80MB
8M x 32 (32MB)	4M x 32 (16MB)	96MB
8M x 32 (32MB)	8M x 32 (32MB)	128MB

960014 - 12

Fig. 3. Example of the possible memory options for a modern Pentium-based motherboard with four 72-pin memory connectors. The smallest memory size that can be fitted is 8 MB, the largest, 128 MB.

Finale: some practical thoughts

Memories for modern computers come in many shapes and sizes, giving the user a hard time to select the proper type when it comes to extending the computer's memory. Among the many questions you may have to ask yourself are: which type of module is already fitted in the computer? Is it ordinary DRAM or EDO-RAM? What is the current capacity per module, and how many connector locations do I have available? What is the processor bus width? How many modules must I install at a time? Is a parity bit required?

By taking a few logic decisions it should not be too difficult to find the right memory extension for your computer. (960014)

switched-capacitor audio filter

In audio engineering there is often a requirement for a filter that either passes or blocks certain frequencies or frequency ranges. This requirement is met by the filter described in this article: the type of filter response required is available at the flick of a switch. The use of a special filter IC from National Semiconductor in conjunction with switched capacitors make the construction and alignment, even for high-order configurations, straightforward. Although the filter is intended primarily for test and measurement, it may also be used for signal enhancement and noise suppression in short-wave receivers and for experimentation in electronic music.

Design by F. Hueber

Technical data

Filter responses:	band-pass, high-pass, low-pass (24 dB/octave), octave band-pass (12 dB/octave), notch
AF pass band	10 Hz – 25 kHz
Filter frequency	20 Hz – 20 kHz
Transfer amplification	1
Output voltage ripple	–0 to +3 dB maximum
Input voltage	5 Vpp (1.76 V rms sine wave) maximum
Input impedance	100 kΩ
Output offset	250 mV maximum
Power requirement	240 V, 2 W

The filter fulfils the same function in measurement technology as in short-wave receivers: it limits the desired frequency band and suppresses noise outside that band. It then operates as a band-pass filter. If, however, a band below a certain frequency, say, 50 Hz, has to be suppressed, it functions as a high-pass filter. Where high-frequency noise or whistles must be suppressed, the filter can be made to work as a low-pass type. If a frequency, say 50 Hz or 100 Hz, within the pass band has to be suppressed, the filter can operate as a notch type. All these types of filter function may prove useful in experiments in electronic music.

The filter IC

The filter is based on a special filter IC from National Semiconductor. This device contains two second-order filter sections, A and B, which can be used separately or in cascade. In either case, they provide a multiplicity of filter configurations.

Each section is designed as a state-variable filter that can function as high-pass, low-pass or band-pass. The great advantage of this setup compared with a discrete design is the simplicity of the circuit and the ease with which the frequency can be reset, even at higher-order functions.

The pinout and circuit of the 20-pin IC are shown in **Fig. 1**. Pin 4 (17) is the input of the device. Pins 1 (20) and 2 (19) are the low-pass and band-pass outputs respectively. Pin 3 (18) is a further output which, according to the switching voltage, provides an all-pass, high-pass or notch characteristic at pins 5 (15-16) and 6 (16). In the present circuit it is arranged to provide a high-pass characteristic.

Pin 15 is the analogue-circuit earth to which the non-inverting terminals of all internal op amps and the reference points of the IC are strapped.

The power supply to analogue and digital circuits is separate via pins 7, 14 and 8, 13 respectively.

STATE-VARIABLE FILTER

A state-variable filter is based on two integrators and an inverter. If the integrator resistors are variable, the filter can easily be tuned. Unfortunately, it is impossible to build a variable resistor into the present IC. Therefore, the switched-capacitor principle is used, which provides a variable filter frequency, fo, that is dependent on the external clock supplied to pin 10 (11).

The equivalence of a resistor and switched capacitor is shown in **Fig. 2.** In case of a resistor, the current, I, is determined by the applied voltage, U, and the resistance, R. In case of a capacitor, the capacitance, C_s, fulfils the same function as the resistance R.

When the switch connects C_s to the input voltage, U, the capacitor is being charged. When the switch position is changed, the capacitor provides (part of) its charge to the output. Thus, in each switching period a certain charge is transferred from input to output.

In this way, an average current, I, flows that is determined by the input voltage, the capacitance of the switched capacitor and the switching frequency, f_s. Thus, the higher the switching frequency, the higher the current. This means that a switched capacitor can replace a variable resistor. The linear relation between the switching frequency and the equivalent admittance of the setup is noteworthy.

A small flaw in the setup is that a tiny part of the switching signal is present in the output signal. In case of a sinusoidal input signal, the output resembles a digitally regenerated sine wave, that is, it looks like a stepped waveform. The amplitude of the steps is proportional to the signal voltage. Fortunately, the frequency of the interfering voltage is much higher than that of the input signal. Thus, it will be virtually undetectable over a wide range of filter frequencies.

In a practical circuit, integrated CMOS switches are used.

Depending on the voltage at pin 12 the clock for IC_1 must be 50–100 times higher than the wanted filter frequency, f_o. With +5 V at pin 12, the multiplication factor is ×50. This arrangement ensures that the internally generated noise of the filter is a minimum. Moreover, the clock at pin 10 (11) must not exceed 1.5 Mhz, which means that with a multiplication factor of ×100, the upper frequency of the filter would be limited to 15 kHz. Note that the factor ×50 must not be taken too literally: it has a tolerance of ±2%; in the prototype, it was 49.4.

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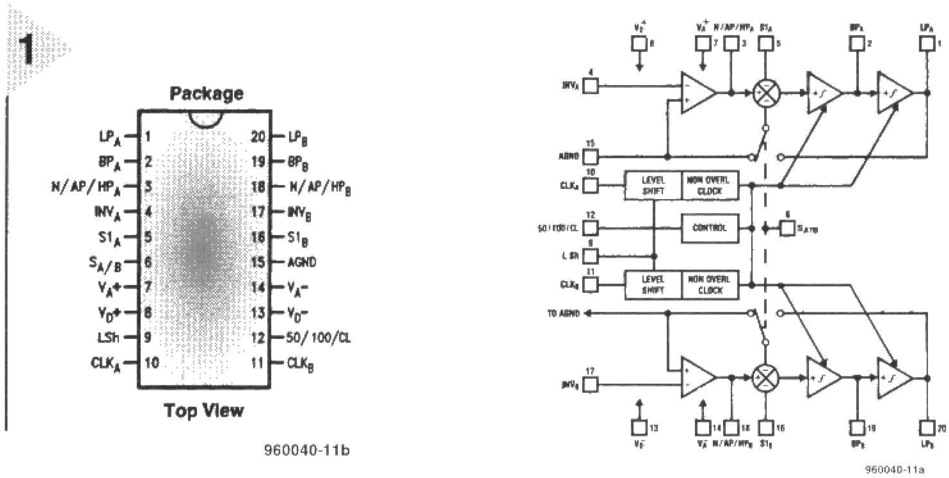

Fig.1. Pinout and circuit of the Type MF10 special filter IC.

THE FILTER PROPER

With the possible exception of the switched-capacitor principle, the function of of the circuit in **Fig. 3** is straightforward.

Circuit IC_2 operates as a bipolar input buffer that is provided with an input protection network, R_1-D_1-D_2.

The voltage drop across R_1 is compensated by the amplification of IC_2, which is set to 1.5 by R_3 and R_4. Capacitor C_2 stabilizes the op amp, since a 5534 is internally compensated only for amplifications exceeding ×3. The offset of IC_2 is compensated with P_1, while its output is taken directly to the input, pin 4, of IC_1.

The low-pass (LP), band-pass (BP) and high-pass (HP) outputs of filter section A of IC_1 are applied to ganged switch array S_1-S_5, which can also select notch filter N and octave filter O. With the switches in positions HP, LP and BP, the outputs of filter section A are applied to the input of filter section B. That is, the two filter sections are cascaded (fourth order filter) to provide a steeper slope of the response curves.

The outputs of filter section B are applied to output buffer IC_{3b} via the switch array.

Output socket K_3 is preceded by low-pass section, R_{24}-C_{22}, which, at least at higher values of f_o, suppresses any residual clock signal at the output.

With the switch array in position N, a notch filter is constructed in summing amplifier IC_{3a} from a combination of the high-pass and low-pass functions of filter section A in IC_1.

The output of IC_{3a} is applied to the output buffer via the switch array. The second section of IC_1 is then not used: its input resistor, R_{13}, is grounded via the switch array.

The band-pass characteristic of the filter is relatively narrow. For cases in which a wider frequency band is needed, an octave-filter has been provided. When the switch array is in position O, the high-pass output of filter section A in IC_1 is applied to section B via the switch array, and then taken from the low-pass output (pin 20). At the same time, S_{1c} ensures that the clock to the first section is half that to the second section. This arrangement provides an upper limit of the HP characteristic which is an octave lower than that of the low-pass characteristic, so that the frequency band between these two points is available at all times.

REMAINDER OF CIRCUIT

The output of IC_1 has a small offset voltage which normally does not affect the operation.

The larger part of the circuit enclosed by the dotted lines is the clock generator, which

Fig. 2. Because of the shift of the charge through the frequency-dependent switch, the setup functions as a variable resistor.

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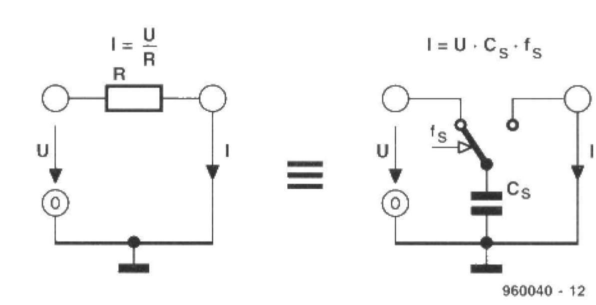

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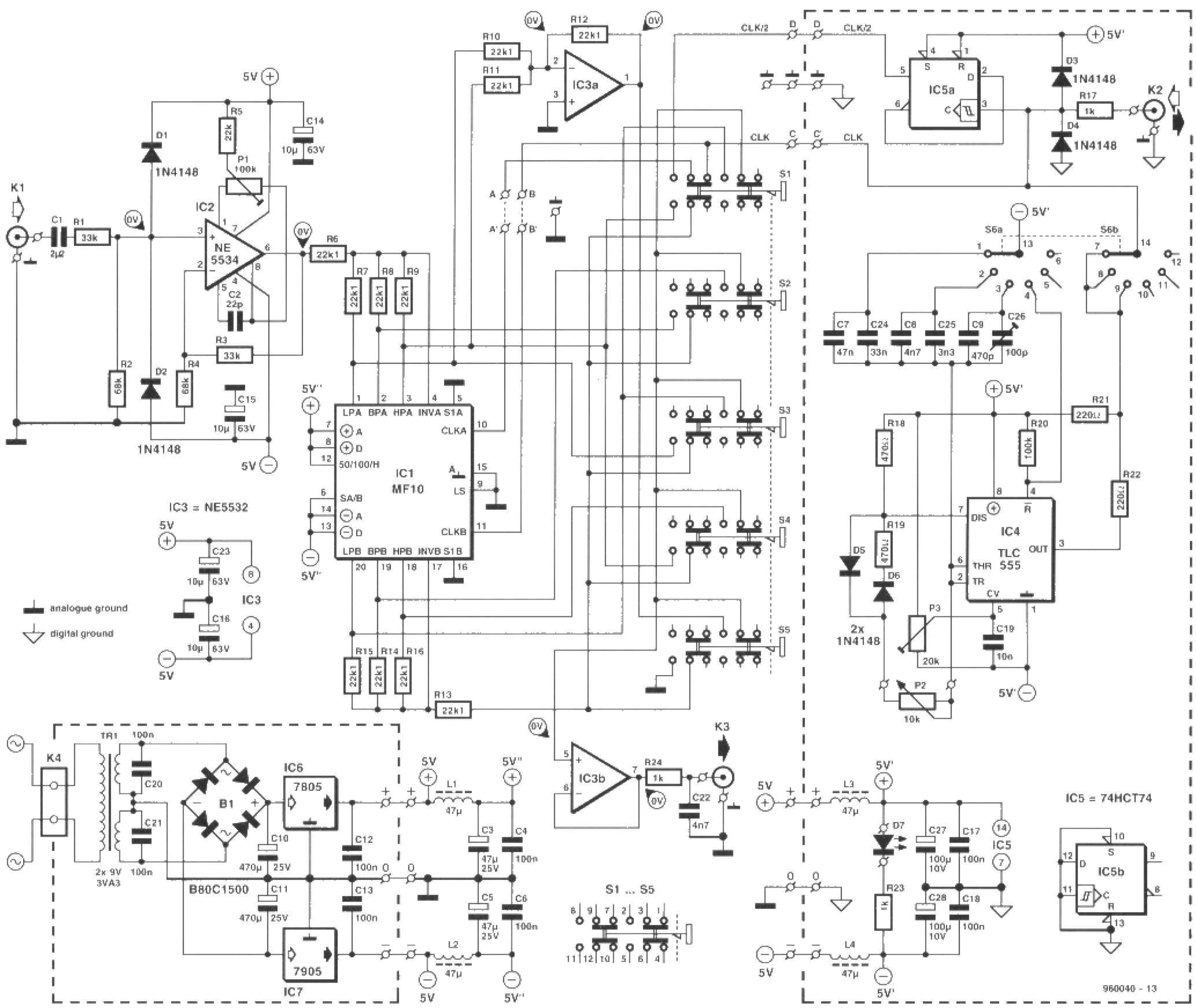


Fig. 3. The circuit of the filter consists of an input buffer, the filter IC, a clock generator and a power supply.

is based on IC_4. Although the manufacturers' data sheet of this CMOS device indicates that it can work up to 500 kHz, it operates with reasonably steep edges to well over 1 Mhz when it is arranged as an astable. Resistors R_{18} and R_{19}, in conjunction with D_5 and D_6, provide a duty factor of 50%, which is required for optimum operation of IC_1. If necessary, the factor can be trimmed to exactly 50% with P_3.

Capacitors C_7–C_9 and C_{24}–C_{26}, which are switched with S_{6a}, and P_2 enable three overlapping frequency ranges to be set: 1–10 kHz, 10–100 kHz, and 0.1–1 Mhz, corresponding to filter frequencies of 20 Hz to 20 kHz.

To ensure troublefree oscillating of IC_4 at high frequencies, the device is switched between –5 V and +5 V. Resistors R_{21} and R_{22} revert the oscillator voltage to TTL level referred to ground.

The clock is applied to pins 10 and 11 of IC_1 direct *and* via S_{1c}.

Half the clock frequency required for filter section *A* of IC_1 when the octave filter function is selected is provided by IC_{5a}, a bistable connected as binary counter.

Socket K_2 has two functions. In standard operation a frequency meter may be connected to it to aid in setting the filter frequency which is $^1/_{50}$ of the measured clock.

In the fourth position of the range switch, IC_4 is disabled via the reset input (S_{6a}) and isolated from the remainder of the circuit by S_{6b}. An external clock with known frequency at TTL level can then be connected to K_2. If the signal is higher than TTL, it will be limited by network R_{17}-D_3-D_4.

The on/off indicator LED, D_7, and its series resistor, R_{23}, are connected between the –ve and +ve supply lines to ensure symmetrical loading of the power supply.

The power supply is a traditional design. The specified transformer is short-circuit proof, so that no fuse is required. Because of its small load (about 38 mA for the oscillator and LED and around 13 mA for the filter), it has ample reserves in spite of its low secondary voltage.

The various filter capacitors in the supply lines ensure that there is no coupling between the clock and the filter channel.

POPULATING THE BOARDS

The filter is built on three printed-circuit boards that are fitted in a small metal enclosure. The filter circuit proper, in line with National Semiconductor recommendations, is built on a double-sided printed-circuit board—see **Fig. 4**. The upper side contains the analogue ground plane and serves as screen. The digital ground is at the underside. The upper side also contains some wire bridges made of insulated circuit wire. The IC sockets must be fitted so that its pins, like the terminals

of some other components, can be soldered at the top as well as at the underside of the board

Switches S_1–S_5 are contained in a ganged push-button array. If this proves difficult or impossible to obtain, different switches may be used, as long as they are ganged. Apart from S_1 (octave function), the switches use only two of the four change-over sections; the other two are grounded to minimize any coupling between clock and filter.

Clock-carrying lines are not provided as tracks on the boards: they are made from discrete, single-screen cable. The screens should be grounded at only one side.

The supply lines are taken from the power supply to the filter board, and from there to the clock generator.

The analogue and digital supply lines are interconnected close to IC_1 and decoupled by C_3–C_6.

Sockets K_1–K_3 are linked to the boards via screened cable. It is advisable to isolate K_2 and K_3 from the enclosure: their ground is then connected to the relevant earthing point via the screen of the cable. Socket K_1, however, is a normal BNC type whose shell is connected directly to the enclosure: this is the only place where the circuit earth is connected to the enclosure.

Components R_{24} and C_{22} are not housed on the board: they are soldered directly to the output socket.

Populate the board in the usual order, starting with the wire bridges, followed by diodes and resistors, and then the larger components. Make sure that none of the components makes contact with the earth plane.

FITTING THE BOARDS

The filter board is fixed at the front on to the ganged switch array and at the rear to the enclosure via two spacers. **Figure 5** shows the layout of the prototype.

Fine clock frequency control P_2 is a 10-turn potentiometer that is screwed on to the board and connected to the relevant tracks via two lengths of flexible. insulated circuit wire. A standard

Aliasing: cause and prevention

When an analogue signal is being sampled, the the sampling frequency, f_{clk}, must be at least twice the signal frequency, fs. If this is not the case, Shannon's theorem predicts that information will get lost. If the sampling frequency is lower than the signal frequency, a signal $f_{s'}$ is retrieved from the sampled information that differs from the original input signal (Nyquist criterion). The retrieved signal—the alias signal—has a frequency that corresponds to the harmonics of the high-frequency components of f_s.

In Fig. A, the upper sinusoidal signal is sampled correctly since $f_{clk} = 8f_s$.

The signal beneath it is sampled at $2f_s$, which meets the Nyquist criterion, but falls foul of Shannon's theorem. The original signal is then sampled correctly only if this is done at amplitudes well above zero; if sampling takes place at the zero crossing, most, if not all, of the information would be lost.

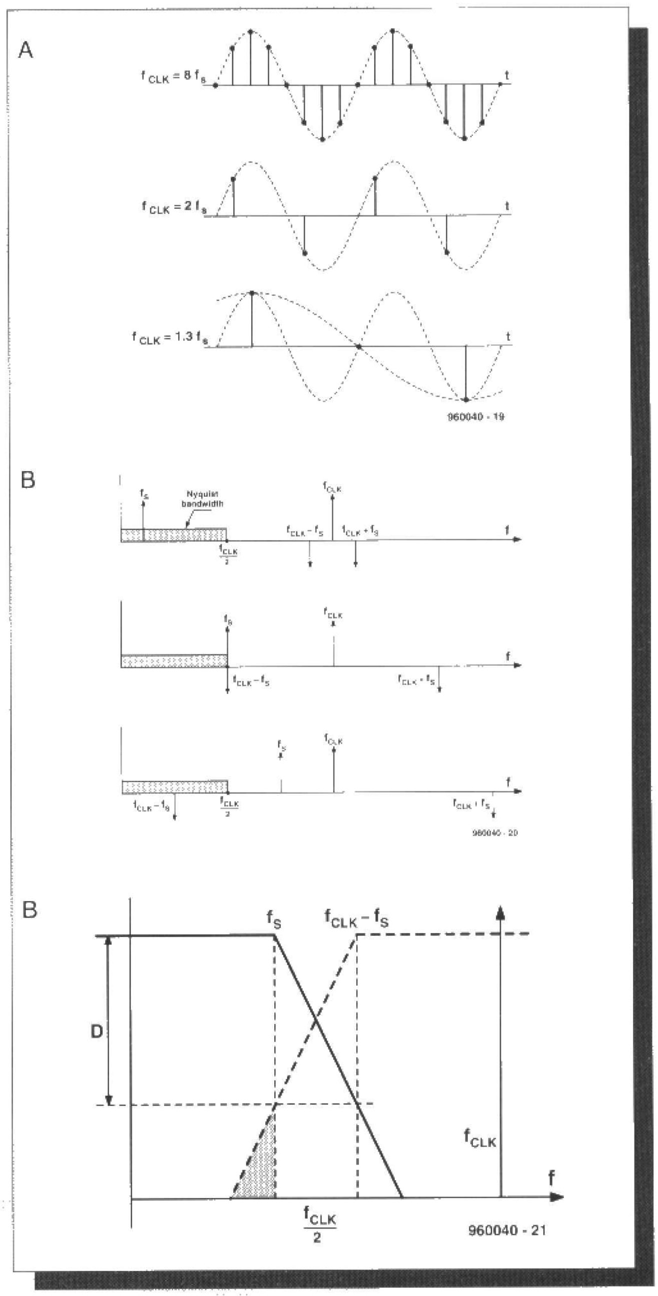
The third signal is sampled at $1.3f_s$, so that, in accordance with Nyquist's criterion, the data of the original signal are lost. The retrieved signal has a frequency that is lower than fs/2.

Even when the requirement $f_{clk} \geq 2f_s$ is met, aliasing components $f_{clk} + f_s$ and $f_{clk} - f_s$ may cause problems as shown in Fig. B. This is because, although the higher alias components are well away from the usable (Nyquist) bandwidth, 0–$f_{clk}/2$, the lower ones may come dangerously close. When $f_{clk} \leq 2f_s$, they may even fall within the Nyquist bandwidth.

The foregoing could lead to the assumption that there are no aliasing problems when the MF10 is used, since the sampling frequency (clock) is $50f_s$ or even $100f_s$ (where f_s is the filter frequency). However, if the input signal is not limited to the Nyquist bandwidth, it is possible in applications with a high upper pass band—high-pass, notch, band-stop—that aliasing components are present in the output signal, even though the clock is much higher than the filter frequency.

Aliasing effects are relatively easily prevented by limiting the input signal to the Nyquist bandwidth with the aid of a suitable low-pass filter before sampling is carried out (Fig. C). The limiting frequency should be as low as feasible. A suitable value is fs, but if there are wanted signal components in the range f_s – $f_{clk}/2$, it must be appropriately higher. The lower alias components then have a limiting frequency of $f_{clk} - f_s$.

The slope is determined by the wanted attenuation of the aliasing components in the range 0—f_s The attenuation results from the dynamic range, D, of the output signal.



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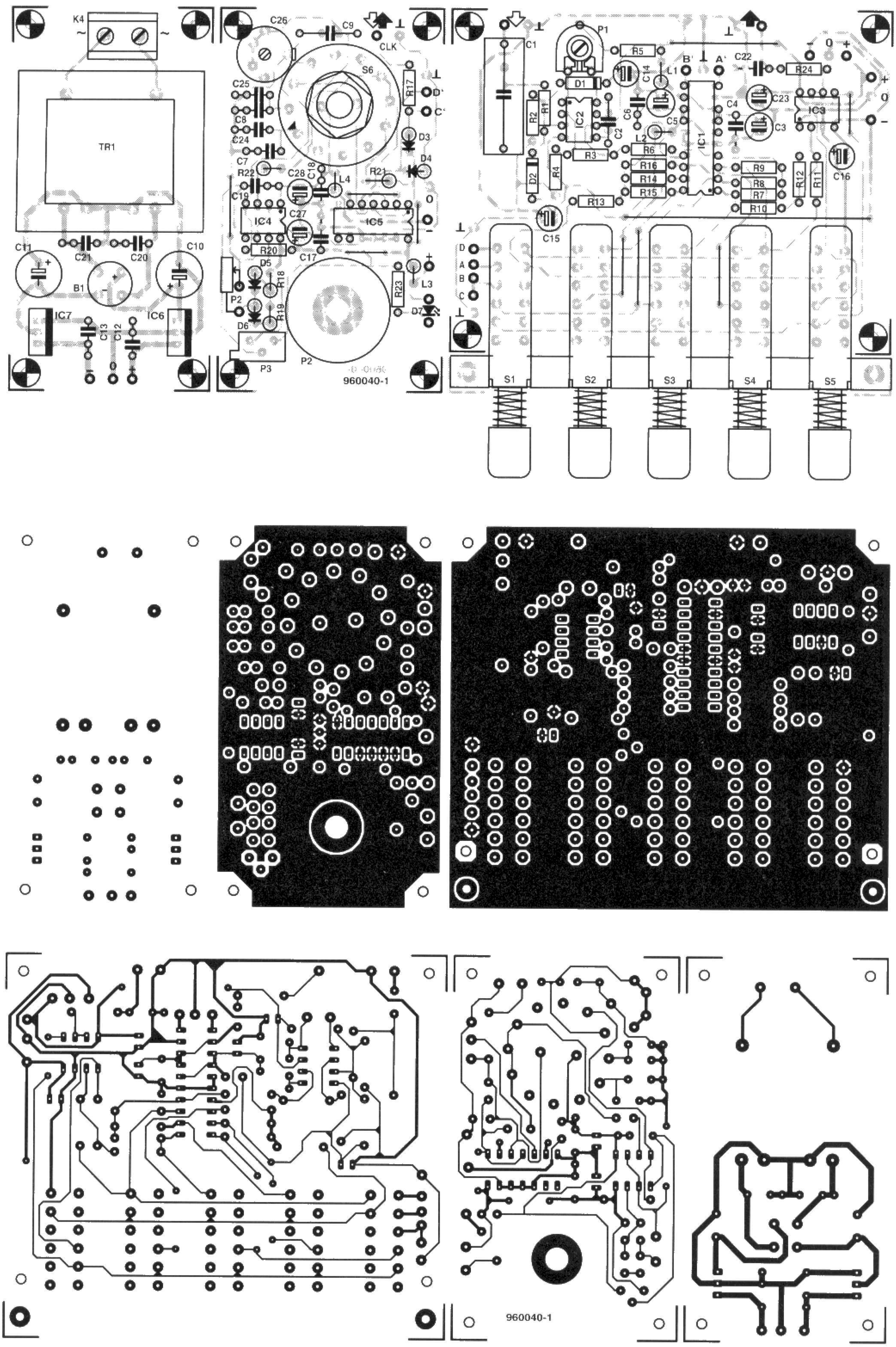

K4
TR1
C11
C21
C20
C10
B1
IC7
IC6
C13
C12
C26
C9
CLK
S6
C25
C8
C24
C7
R22
C19
C28
C18
L4
R21
IC4
IC5
C27
R20
C17
D5
R18
P2
R19
D6
P3
R17
D3
D4
R23
L3
D7
960040-1
C1
P1
R5
D1
R1
R2
IC2
C2
C6
C14
L1
C5
L2
R3
R4
D2
R6
R16
R14
R15
R13
C15
IC1
C22
R24
C4
C23
C3
IC3
R9
R8
R7
R10
R12
R11
C16
S1
S2
S3
S4
S5
960040-1

Fig. 4. The double-sided PCB must be cut into three before any work is done on it.

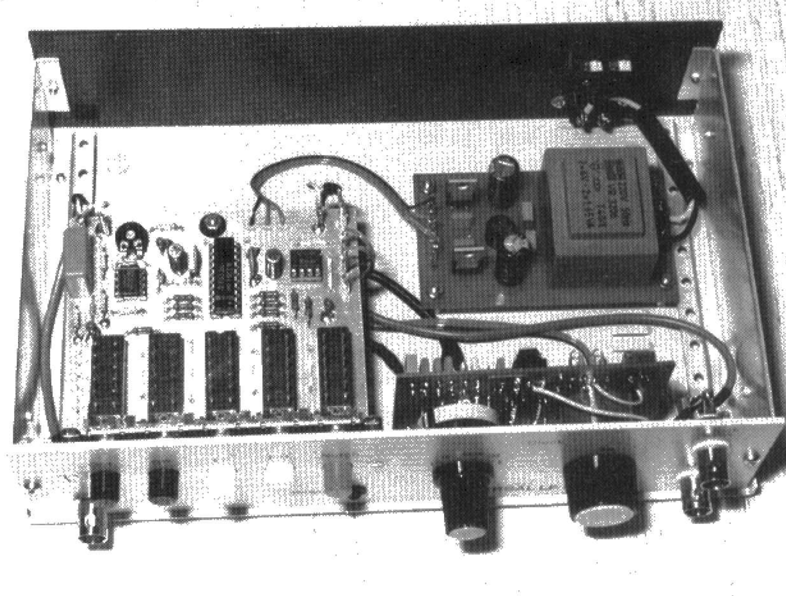


Fig. 5. General view of the prototype filter with top cover removed.

potentiometer is less expensive, but, to ensure that high frequencies can be set readily within the relevant range, it should have a negative logarithmic characteristic.

Rotary switch S_6 is soldered directly on to the board.

The supply board is fitted next to the oscillator board on four 10 mm long spacers. The mains on/off switch is fitted on to the rear panel.

Parts list

Resistors:
R_1, R_3 = 33 kΩ
R_2, R_4 = 68 kΩ
R_5 = 22 kΩ
R_6–R_{16} = 22.1 kΩ, 1%
R_{17}, R_{23}, R_{24} = 1 kΩ
R_{18}, R_{19} = 470 Ω
R_{20} = 100 kΩ
R_{21}, R_{22} = 220 Ω
P_1 = 100 kΩ preset
P_2 = 10 kΩ, 10-turn potentiometer
P_3 = 20 kΩ multiturn preset

Capacitors:
C_1 = 2.2 μF, polypropylene, pitch 5 mm
C_2 = 22 pF, 160 V, polyester
C_3, C_5 = 47 μF, 25 V, vertical
C_4, C_6, C_{12}, C_{13}, C_{17}, C_{18}, C_{20}, C_{21} = 100 nF, ceramic
C_7 = 47 nF
C_8, C_{22} = 4.7 nF
C_9 = 470 pF, 160 V, polyester
C_{10}, C_{11} = 470 μF, 25 V, vertical
C_{14}–C_{16}, C_{23} = 10 μF, 63 V, vertical
C_{19} = 10 nF
C_{24} = 33 nF
C_{25} = 3.3 nF
C_{26} = 100 pF trimmer
C_{27}, C_{28} = 100 μF, 10 V, vertical

Inductors:
L_1–L_4 = 47 μF

Semiconductors:
D_1–D_6 = 1N4148
D_7 = LED, red, 3 mm or 5 mm

Integrated circuits:
IC1 = MF10CCN (National Semiconductor)
IC_2 = NE5534
IC_3 = NE5532
IC_4 = TLC555
IC_5 = 74HCT74
IC_6 = 7805
IC_7 = 7905

Miscellaneous:
K_1–K_3 = BNC socket for board mounting
K_4 = 2-way terminal block for board mounting, pitch 7.5 mm
S_1–S_5 = 5-way ganged push-button switch array
S_6 = rotary switch, 2 pole, 6 position for board mounting
B_1 = rectifier B80C1500, round
Tr_1 = mains transformer, 2×9 V secondary, 3.3 VA

ALIGNMENT

When the boards have been populated, do not yet insert the ICs into their sockets. Set P_1 and P_3 to the centre of their travel, switch on the mains (the on/off indicator LED forms the basic load for the power supply) and check that the supply voltages at various points are correct. Switch off the mains and insert the ICs into their socket.

Check that the clock generator functions correctly: ranges 1–10 kHz and 10–100 kHz should present no difficulties. With an oscilloscope and 10:1 probe, check the wave form and duty factor. If necessary, adjust P_3 until the factor is exactly 50%. This setting **must** be carried out before the final check of the end of the range, which is carried out with a frequency meter connected to K_2.

Next, align the 0.1–1 Mhz range in the same way as the other ranges, which, owing to the trimmer, should present no difficulties. The frequency at pin 5 of IC_5 should be half that at K_2.

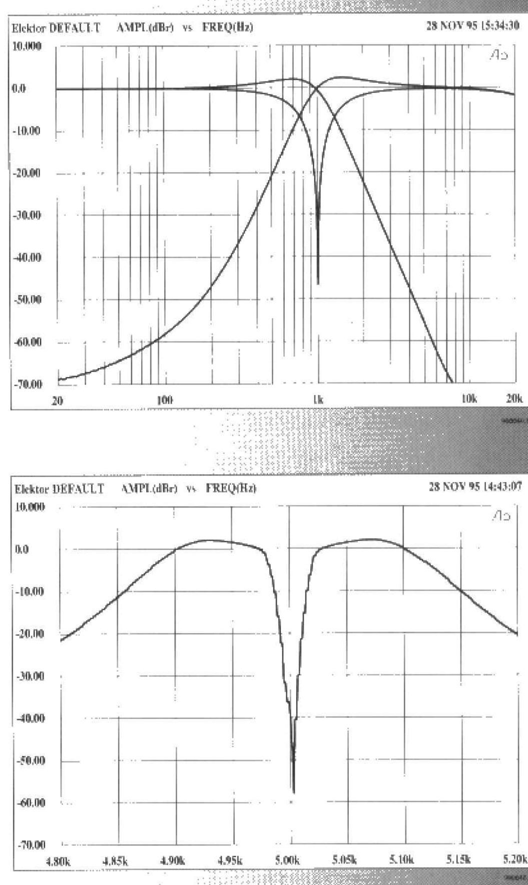
Apart from compensating the offset of IC_2, there are no alignments on the filter board. The offset voltage of IC_2, measured between pin 6 and ground, is set to zero with P_1.

Input a signal of exactly 1 kHz and set the filter function to NOTCH. Set S_{6a} to position 2, adjust P_2 until the output voltage is a minimum, and measure the clock at K_2. The measured value is the clock factor. Since finding the minimum output voltage is tedious, it is advisable to repeat the adjustment and measurement a couple of times to get a good average.

Figure 6 shows the frequency response curves of the individual filter types. These curves have been normalized and are obtained with the minimum deviation from f_0 in all cases.

(960040)

Fig. 6. Normalized transfer functions of the MF10.



PIC-CONTROLLED RDS DECODER

a compact Radio Data System decoder for any FM stereo radio

The Radio Data System (RDS) is now well established among VHF-FM broadcasters aiming at providing additional information with their radio programmes. In addition to up-to-date traffic information, RDS also brings you, on an LCD screen, alternative frequencies, time information and a feature called Radiotext. The latter in particular is on the rise these days, with an increasing number of stations offering this additional information to listeners at home and in their cars. A PIC16C84 microcontroller allows a simple and pretty compact RDS add-on decoder to be built based on only two integrated circuits.

Design by U. Nagel

Main Specifications

- Continuous display of station name, time and radiotext
- Traffic announcement indicator
- Simple design, only two ICs and a voltage regulator
- Extremely sensitive
- Compact, complete with LCD module
- Powered by FM receiver (on-board 5-V regulator, low current consumption)
- Alignment-free demodulator

Apart from the traffic-related functions aimed at the car radio market, other RDS functions such as transmitter identification, time and radiotext are of great interest to owners of home based FM radios. The RDS decoder presented here was developed to function as a simple extension to any (we hope) domestic FM stereo receiver. The circuit displays the station name, time (with atomic accuracy from some transmitters) and radiotext on a 2×16 or 1×40 character liquid screen display (LCD). The printed circuit board for this project is compact at just 84×44 mm, and matches the size of a 2×16-character LCD unit.

THE CIRCUIT

RDS processor IC1 contains everything you need to demodulate the RDS data signal taken from an FM receiver. We are talking about the TDA7330 from SGS-Thomson, a chip that contains RDS subcarrier filters as well as a dedicated demodulator. The filter is alignment-free thanks to a quartz-controlled switched-capacitor network. Obviously, the total absence of adjustment points on the RDS demodulator chip is a great help in keeping the construction of the RDS de-

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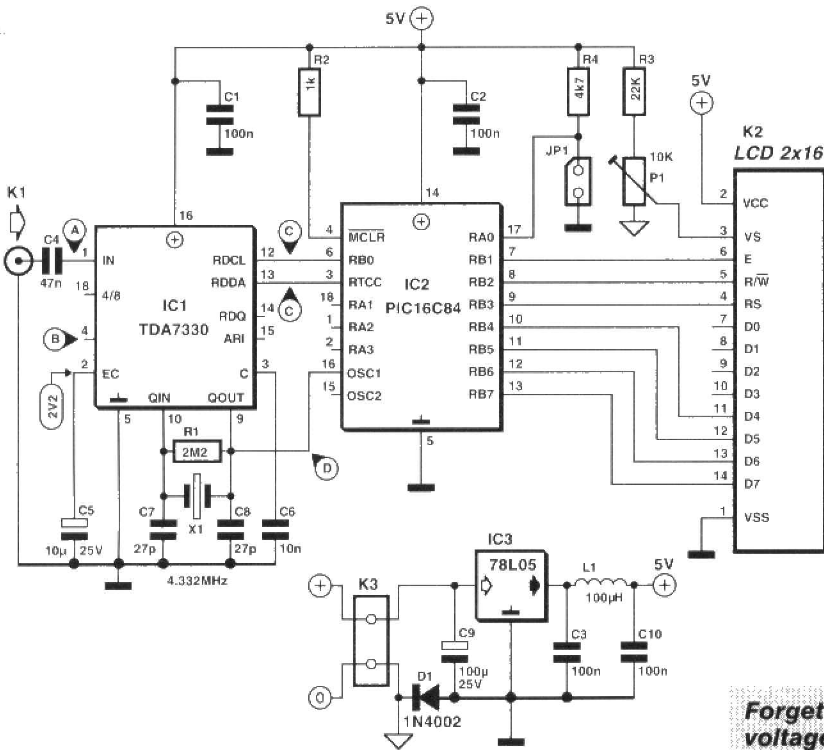


coder as simple as possible.

A supply voltage of 5 V is required to power the RDS decoder. The decoder supplies the familiar set of RDS output signals: RDS CLOCK (pin 12), RDS DATA (pin 13), RDS QUALITY (pin 14) and ARI (Autofahrer Radio Information, for Germany only) (pin 15). The TDA7330 may be used with a 4.332-MHz or an 8.664-MHz quartz crystal. The first option is selected by leaving pin 18 open-circuited, the latter, by strapping pin 18 to +5 V. Here, an oscillator frequency of 4.332-MHz is used, which doubles as the clock for the PIC, allowing this device to work without its on-chip oscillator.

Design information on the TDA7330 is given on the *Elektor Electronics* Datasheet elsewhere in this issue. The input of the demodulator chip is supplied with the multiplex (MPX) signal, which is 'stolen' from the **input** of the stereo decoder in the FM receiver. Only two of the previously mentioned RDS outputs are used here, namely the RDS data signal (RDDA, pin 13) and the associated clock (RDCL, pin 12). The clock frequency equals 57,000/28 Hz, i.e., 1187.5 Hz. It is used to produce an interrupt at processor pin RB0. In the interrupt routine, the processor reads the data signal at its RTTC pin (pin 3 of the PIC).

The liquid crystal display (LCD) is operated in four-bit mode, in which only D4 through D7 are used. Data lines D0, D1, D2 and D3 are, therefore, not used. RB1, RB2 and RB3 are the control signals for the display.

Jumper JP1 selects the LCD type used: JP1 open = 2×16 characters; JP1 closed = 1×40-characters. The contrast on the LCD is adjusted with preset P1. Voltage regulator IC3 allows the decoder to be powered from a supply voltage higher than 5 V, which may be available in the FM receiver. Current consumption of the decoder is smaller than 15 mA. Diode D1 acts as a supply reversal protection, and at the same time creates a an auxiliary bias of −0.7 V which is applied to the lower terminal of preset P1. The use of a (small) negative voltage ensures that older LCDs, too, can be made to produce sufficient contrast. Because the PIC processor combines everything that belongs in a computer on a single chip, it emits only low interference levels, reducing the main sources of noise to the LCD connections, which should be kept as short as possible. Actually, that is why the LCD is fitted directly on to the decoder board.

Construction and connection

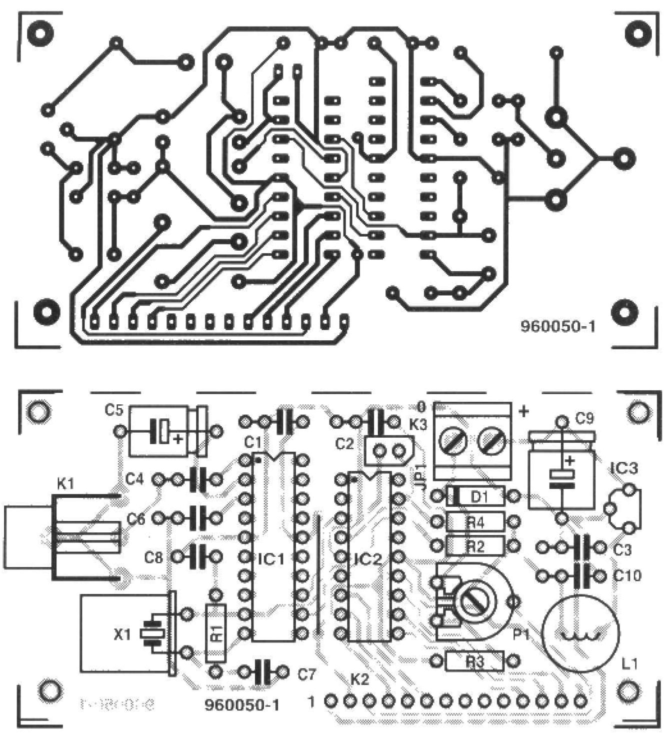
The single-sided printed circuit board is simple to populate. If you go for minimum cost, give at least the PIC an IC socket. The display is secured at the solder side of the board with the aid of short wires or header/socket connections, so that the solder sides face one another. Although the noise emission of the decoder/display unit will be low, it does no harm to fit the project in a screened metal enclosure. In most cases, however, an all-plastic case will be equally suitable. The board has a cinch socket via which the multiplex signal is applied. Before taking the RDS decoder into use, you should make sure the board is correctly populated. Also check the use of the jumper (see above). For an initial test, power the decoder from a direct voltage source supplying anything between 9 and about 12 V, for example, your benchtop regulated d.c. power supply. You will also need a properly working FM radio with 'line' outputs. This may be an FM stereo tuner or a mono radio with a tape recorder output. With most high-end FM stereo tuners, the multiplex signal is suppressed to the extent that the RDS decoder will not be able to detect even the smallest trace of it at the receiver's line outputs. On most down-market FM radios, however, as well as on many mono receivers with a line (tape recorder) output, it is definitely worth trying the audio outputs! With stereo tuners, it makes no difference whether you use the left or right line output. It is, however, essential to have the receiver tuned to a strong signal from a station of which you are certain it transmits RDS.

Forgetting about the voltage regulator for the moment, an RDS decoder can be built from just a demodulator IC, a programmed PIC and a standard LCD module

On being switched on, the RDS decoder produces an identification which remains on the LCD until a valid RDS signal is detected and processed. The identification may be used to adjust the LCD contrast.

Once a valid multiplex signal is received at the input of the decoder, the display shows the station name, for example, BBC R1, almost immediately after the power-on ident has disappeared. After a further minute or so, the time also appears on the display, next to the station ident. When you

2



Track layout and component overlay of the single-sided printed circuit board (available ready-made, see page 70).

Components List

Resistors:
R1 = 2MΩ2
R2 = 1kΩ
R3 = 22kΩ
R4 = 4kΩ7
P1 = 10kΩ preset

Capacitors:
C1,C2,C3,C10 = 100nF
C4 = 47nF
C5 = 10μF 25V
C7,C8 = 27pF
C9 = 100μF 25V
C6 = 10nF

Inductor:
L1 = 100μH choke

Semiconductors:
D1 = 1N4002
IC1 = TDA7330 (SGS-Thomson)
IC2 = PIC16C84 (programmed, order code 966505-1)
IC3 = 78L05

Miscellaneous:
K1 = PCB-mount cinch socket
K2 = LCD, 2x16 or 1x40 characters. Preferred type: Sharp LM16A21 (2x16)
K3 = 2-way PCB terminal block, 5mm raster.
X1 = 4.332-MHz quartz crystal
Printed circuit board and programmed PIC for this project: order code 960050-C (see page 70)

are receiving a traffic information station, the display shows a '-' (dash) at the far right. This changes to a '*' when traffic information is transmitted.

The lower display line shows the radiotext (if available), which scrolls. Up to two messages of 64 characters may be transmitted. These are joined to give one 128-character text, which is displayed sequentially.

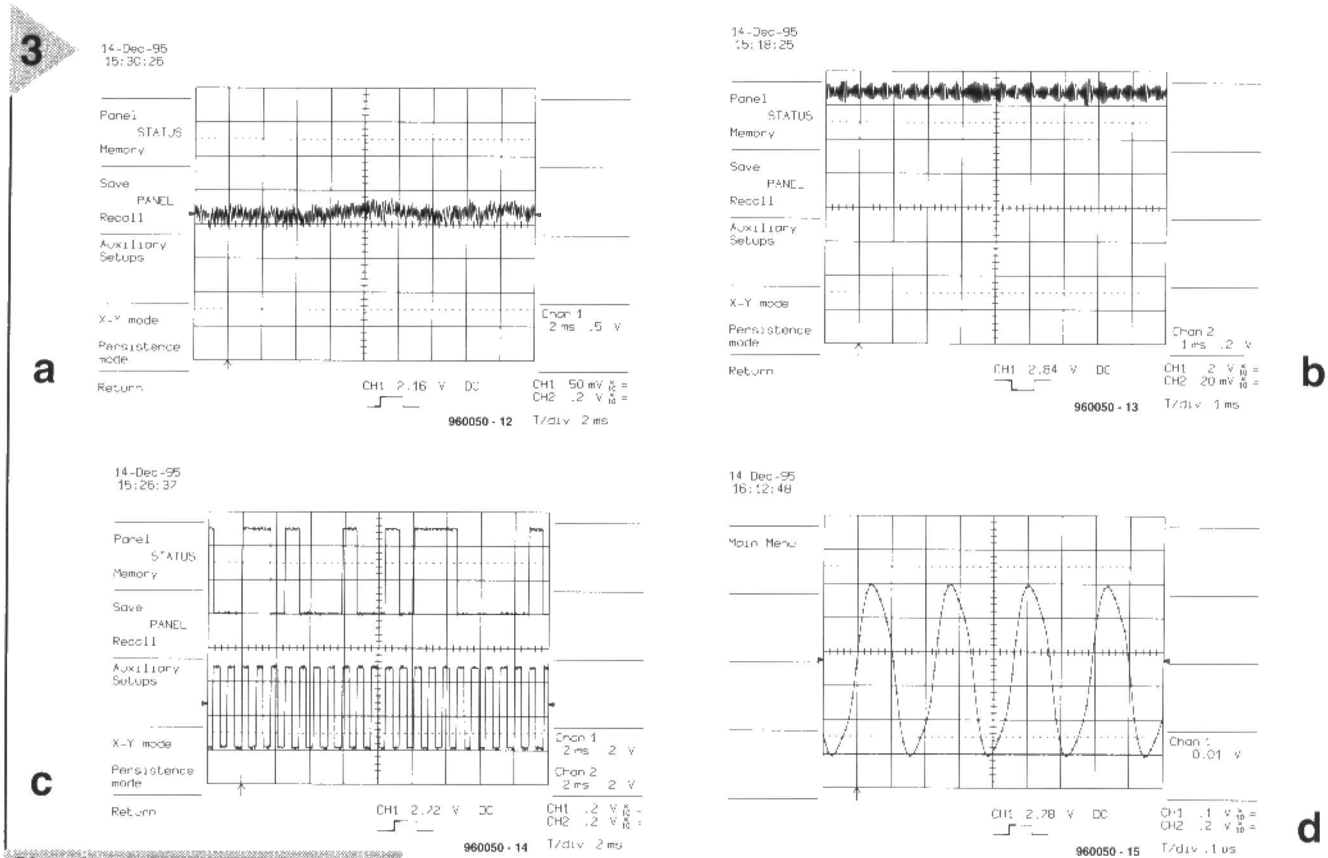
If you are unable to achieve usable results from the receiver's line output(s), there is no alternative but to locate the MPX signal inside the tuner, at the input of the stereo decoder. As shown by the block diagram of a typical FM tuner, **Fig. 5**, this point is found near the FM demodulator, where the demodulated FM multiplex signal 'before de-emphasis' is available. The actual point to tap is easily found using the receiver's service documentation and/or your oscilloscope. If have neither of these, it is also possible to find the MPX signal by trial and error. Starting from the receiver's cinch output sockets, trace the wires or PCB tracks that lead to the stereo decoder IC. Once you have located this IC, the first thing to do is make sure your are tuned to a station of which you are certain it transmits RDS. Next, carefully touch each of the decoder IC pins with a probe connected to the RDS decoder input. Because of the processing time needed by the RDS demodulator, you may have to keep the probe connected at least 30 seconds to each pin before data starts to appear on the display. Once the right pin is found, the station name is displayed after a short while, followed by radiotext (if transmitted).

Having found the proper signal for the decoder's MPX input, the unit may be installed and wired permanently, either inside the receiver, or as a set-top extension. If you choose to fit the decoder in the receiver case, you will need to locate a suitable take-off point for the 9-V supply voltage. Hopefully, that is not too difficult to find in the receiver. The signal connection between the tuner and the decoder is best made in thin screened cable. If the supply voltage is also taken from the receiver, the cable screening may be connected to ground at one side only: the receiver side! This is necessary because of the polarity reversal protection diode, D1, which would otherwise be shorted out, causing lower contrast on the display.

TEST VALUES AND TROUBLESHOOTING

The circuit diagram, **Fig. 1**, gives you a number of d.c. test values as well as points at which active signals can be measured. The relevant signals, measured on our prototype, are shown in **Fig. 3**.

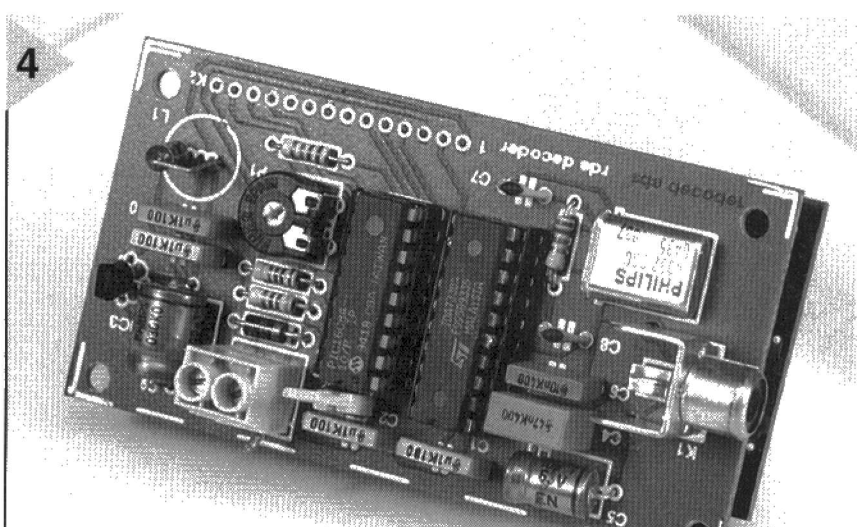
While measuring the direct voltages in the circuit, you should note that pin marked '0' on K3 does **not** represent ground. This is actually at −0.7 V because of diode D1 (whose anode is at ground potential). For measurement purposes, ground may be taken from, for example, the negative terminal of C9, or the cable screening terminal of the cinch socket. In addition to the operating voltage (5 V) and the reference voltage (approx. 2.2 V at pin 2) you may also want to measure the logic levels at pins 14 (RDQ) and 15 (ARI) using a digital multimeter. RDQ (designated QUAL in the datasheets) indicates the quality of the received RDS signal. This pin supplies a logic high level when an RDS signal of sufficient quality is received. RDQ is low when the RDS input signal is too small, or missing. The ARI pin goes high when an ARI signal is being received, and low when only an RDS signal is available. The level of the ARI pin in undetermined when neither RDS nor ARI is being received. In the UK, the



Signals at the measuring points indicated in the circuit diagram: (a) stereo multiplex signal; (b) filtered 57-kHz signal; (c) RDS data signal (upper trace) and recovered 1187.5-Hz bit clock signal (lower trace); (d) 4.332-MHz oscillator signal.

ARI system is not used.

The signals at the other measuring points, A through D, are shown in **Fig. 3**: the multiplex signal (**Fig. 3a**), the filtered 57-kHz signal with RDS and ARI (**Fig. 3b**), the recovered bit clock and data signals (**Fig 3c**) and, finally, the oscillator signal (**Fig. 3d**). The levels supplied by pin 14 (RDQ/QUAL) and pin 15 (ARI) are easily evaluated with a multimeter to give a go/no-go verdict on the operation of the RDS demodulator chip. If the levels measured do not make sense, you may have hit upon a station that does not transmit RDS. If you are sure, however, that you are tuned to the right station, then a low level at the RDS output (and possibly at ARI also) indicates that the tuner either does not supply an MPX signal (wrong internal connection), or the MPX signal is too small. The latter is unlikely, however, because the TDA7330 boasts a sensitivity of 1 mV for RDS signals and 3 mV for ARI signals (see datasheet extracts elsewhere in this issue). Without the help of an oscilloscope, you may have to solve this problem by trying out another receiver, or finding another point in the receiver to tap the unfiltered MPX signal.



Fully populated prototype board. The LC display may be plugged in at the solder side of the decoder board. That results in a compact RDS decoder module which is eminently suited to installing in an existing FM tuner.

When IC1 reports an RDS signal (pin 14 goes high), the LC display should at least indicate the station name after a few seconds. If the power-on message does not appear at all, the first thing to check is the LCD contrast setting. If another display is used than the one mentioned in the parts list, it could just be that the connections are turned 180 degrees (this is the case particularly with older LCD models). When the display does not show a dark line at

any setting of P1, and with all ICs removed from the decoder, you should simply try to reverse all connections by 180°.

When the display works all right, and the TDA7330 reports RDS reception at pin 14, the only remaining source of trouble is really the oscillator. The oscillator signal at pin 16 may be checked with an oscilloscope, just like the signals at pin 3 (RDS data) and pin 6 (RDS bit clock). Assuming that these signals are okay, and the display is working and connected the right way around, it is time for a thorough check on all solder joints and PCB tracks around the PIC on the board. If you can't find an error, the PIC may be damaged electrically, which may be ascertained by exchanging the device. Although it rarely happens in practice, it can not be ruled out that the CMOS controller has become the victim of a static discharge or overheating. (960050)

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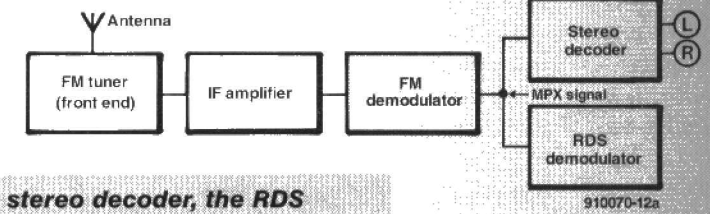


Like any stereo decoder, the RDS demodulator/decoder has to be supplied with the stereo MPX (multiplex) signal, which is available at the output of the receiver's FM demodulator.

For further reading:

Radio Data System (RDS) decoder, *Elektor Electronics* May 1989.

Radio Data Systems, *Elektor Electronics* July/August 1991.

Radio Data System (RDS) decoder, *Elektor Electronics* February 1991.

RDS demodulator with integrated filter, *Elektor Electronics* October 1992.

Radio Data System (RDS) decoder, *Elektor Electronics* May 1993.

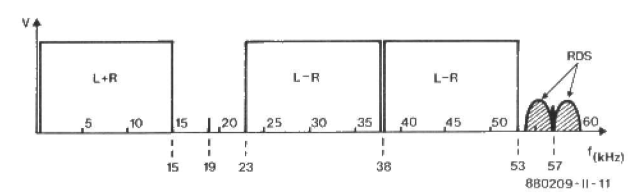
Radio Data System (RDS) decoder, *Elektor Electronics* January 1994.

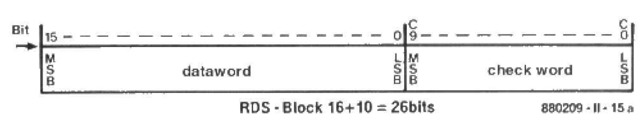
R·D·S for dummies

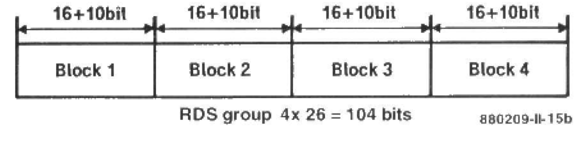
RADIO DATA SYSTEM

Radio Data System (RDS) information has been transmitted by many VHF-FM radio stations since 1988. RDS signals are conveyed at a subcarrier frequency of 57 kHz. This frequency is phase-locked to the pilot carrier of 19 kHz (3×19 kHz = 57 kHz). Figure 1 shows the theoretical frequency spectrum of the multiplex signal as transmitted by a VHF-FM radio station broadcasting RDS. RDS data is modulated using a technique known as double-sideband suppressed carrier (DSSC), which results in two clearly visible sidebands whose bandwidth is roughly equal to the binary RDS data rate of 1187.5 bits per second (baud). The bit clock is recovered from the subcarrier by dividing it by 48. That also explains why a frequency of 1187.5 Hz is available at the clock output (RDCL, pin 12) of the RDS demodulator IC TDA7330, provided, of course, a valid RDS signal is being received.

Basically, the RDS signal consists of binary data which are transmitted serially. This data is organized in blocks of 26 bits each. Each block contains a 16-bit dataword and a 10-bit checkword (Fig. 2a). The high redundancy of the checkword affords security of the data even under very adverse receiving conditions such as in a moving car. Four 26-bit blocks together form a 104-bit ***group****. In a group, the blocks are simply identified by their order, i.e., Block 1 through Block 4 (Fig. 2b). Blocks and groups are transmitted continuously, so that the transmission time per group equals 87.5 ms at the above mentioned baudrate. Each RDS group is of a certain* ***type****. RDS supports 15 group types. The following information is contained in all groups: programme identification (PI), programme type (PTY) and traffic (TP). The rest of the information conveyed in the group is variable, and depends on the group type.*
The information type list is long, and extends from data/clock info (Type 4 Group), through internal information on the radio station (Type 6 Group), right up to a transparent data channel (TDC, Type 5 Group) which is intended to convey small computer programs or even GPS correction data.
The Radiotext (RT) as displayed by the present decoder is contained in type-2 groups, and consists of up to 64 characters which supply any information the broadcasters feel free to throw at you, usually related to the currently transmitted programme. RT supports spaces, enabling the text to be easily read from a 2×32 display. In principle, it is also possible to transmit texts of any length in successive lines (64-character chunks). In practice, however, that is rarely done. Apart from the low transmission rate that can be achieved (no more than about 20 characters per second, provided every alternate group contains RT), the main objection against using long texts is probably that the broadcasters are painfully aware of the relatively low number of people who are willing and able to receive and read radiotext. Hopefully, that situation changes for the better following the publication of this article.





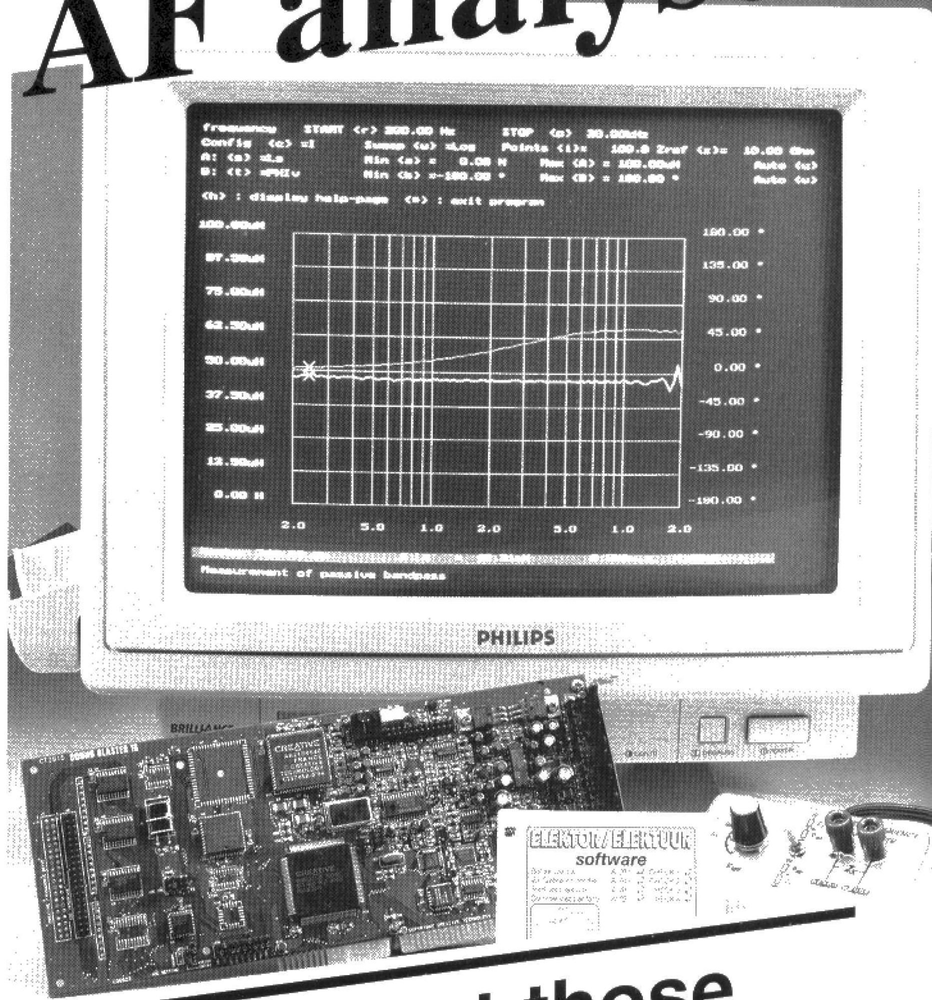


PC soundcard as AF analyser

PART 1

An ordinary PC with a 16-bit sound card is turned into an excellent audio-frequency measuring system, at a very small outlay, just by running some clever software. Applications of the PC-controlled AF analyser include measuring frequency and phase response of amplifiers, filters and, in particular, loudspeaker cross-overs. But that's not all because the analyser also enables you to determine the impedance of loudspeakers, the inductance of coils, or the capacitance of capacitors. A noticeable feature of the analyser is its wide measuring range, for instance, from 50 μH to 100 μH for inductors, and 100 pF to 100,000 μF for capacitors.

Software by Dr. M. Ohsmann



check out those amplifiers and filters

Just think of it: a state-of-the-art sound card like the Soundblaster 16 VE will set you back less than 70 pounds, yet it contains, among others, a stereo 16-bit analogue-to-digital converter (ADC) for 44-kHz sampling, as well as an FM synthesizer chip capable of generating complex waveforms. No wonder you may want to make all this high-tech stuff do a bit more than produce PC game noises of the *whizz-bang* class. One such 'serious' application which is of special interest to electronics engineers and hobbyists alike is the versatile AF analyser station described in this two-part article. This first part deals with the main possibilities of the measurement system, while next month's second and final part tackles the operation of the software developed for the project. It will also discuss a small add-on box for measurements. The box contains a couple of resistors and switches, and turns the PC in a multi-purpose impedance measuring station.

For example

To begin with, the main technical features of the analyser system will be discussed by means of a couple of examples.

Frequency response of an amplifier

The graph in **Fig. 1** is the result of a measurement performed on the audio power amplifier in a low-cost car radio. A non-reactive load was driven. The frequency response was recorded over a range from 20 Hz to 20 kHz. It is seen that frequencies around 100 Hz get an extra 'boost'. The 'bass' control was turned up for this measurement. Clearly, the frequency response starts to drop at about 5 kHz. The phase response is not very linear either.

Impedance graph of a loudspeaker

The results of an impedance measurement on a loudspeaker system are shown by the graphs in **Fig. 2**. The measurement was performed on a co-axial drive unit (i.e., one with the tweeter located centrally in the woofer/midrange speaker) which was claimed to have a nominal impedance of 4 Ω over the frequency range from 20 Hz to 20 kHz. The graph shows the real part (resistance) and the imaginary part (reactance) of the loudspeaker's complex impedance. The marker is set at 122 Hz, where the first self-resonance of the drive unit occurs. Where the real part goes through a maximum of about 20 Ω, the imaginary part shows a zero crossing. The second self-resonance point occurs at about 5 kHz, where the impedance rises to nearly 7 Ω. As you can see, the measurement system is capable of capturing all essential details of an impedance response.

Inductance measurement on an RF choke

Figure 3 shows that the value of an RF choke rated at 40 μH can still be measured with confidence. Obviously, such a measurement calls for the highest frequencies the analyser is capable of producing. In the example, the measurement was carried out over a frequency range from 5 kHz to 20 kHz. The measured inductance (approx. 40 μH) is shown in the top part of the illustration. The lower part shows the resistance of the choke, which amounts to about 1 Ω (at a measurement error of about 100 mΩ). You guessed it: the AF analyser is an excellent help when you have to wind RF coils yourself. But low-frequency coils, too, can be measured without problems, for example, those in loudspeaker filters which have values in the milli-henry range.

1

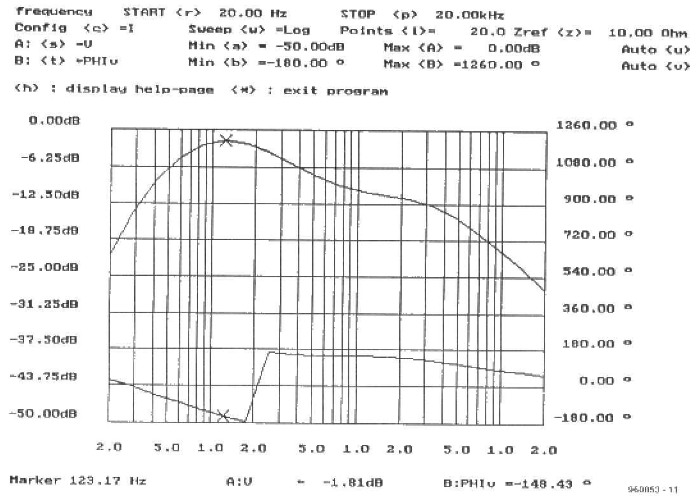


Fig. 1. Results of a phase/frequency response measurement on a low-cost car radio AF amplifier.

2

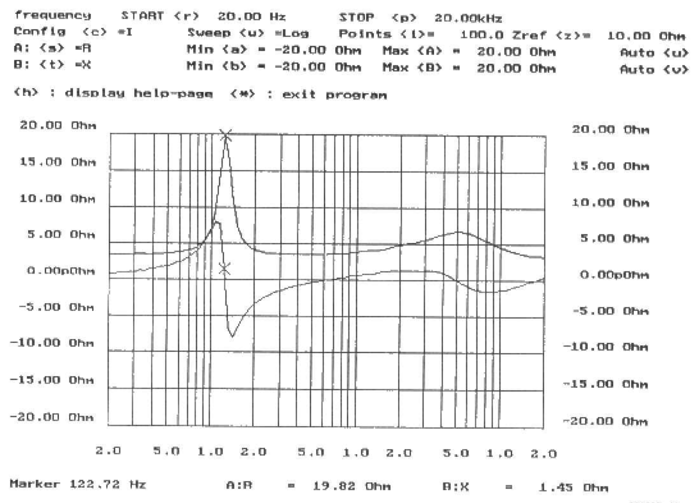


Fig. 2. Measured impedance response of a loudspeaker drive unit.

3

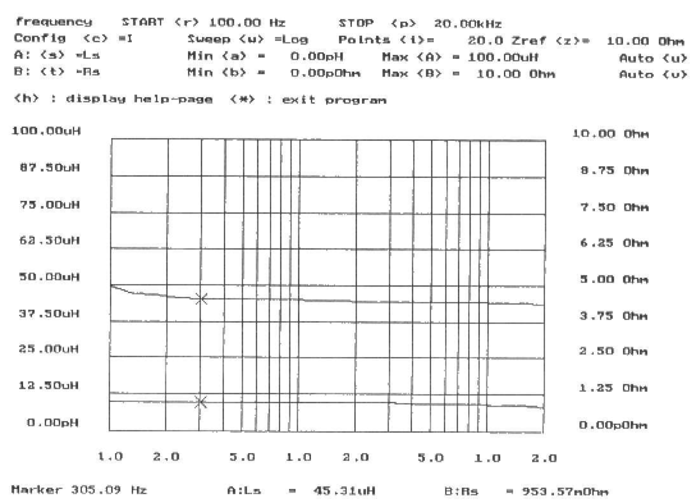


Fig. 3. Even a 40-µH RF choke can be checked out.

MEASUREMENT OPTIONS OF AF ANALYSER

Frequency response (level and phase) of

- ☆ *amplifiers*
- ☆ *filters*
- ☆ *loudspeaker cross-over filters*
- ☆ *control loops*

Impedance measurement on two-poles

- ☆ *loudspeaker parameters*
- ☆ *filter inductors*
- ☆ *(electrolytic) capacitors*
- ☆ *resistors*
- ☆ *input/output impedance of filters*
- ☆ *inductors, even smaller than 50 μH*

MINIMUM PC REQUIREMENTS FOR AF ANALYSER

PC:	*486DX-80 with VGA colour graphics*
Sound card:	*16-bit SoundBlaster VE (Creative Labs)*
Software:	*AF-Analyser program (DOS), published by Elektor Electronics*

MAIN TECHNICAL DATA

- ☆ *Frequency range 15 Hz to 20 kHz*
- ☆ *Freely selectable start/stop frequency*
- ☆ *Sweep: logarithmic or linear, up to 1,000 measurement points*
- ☆ *Marker function for accurate indication of measured values*
- ☆ *On-line help function*
- ☆ *Readout in dB, degrees, Ω, F, H (auto-ranging)*
- ☆ *16 bit theoretical resolution*
- ☆ *Measures gain, phase and frequency response*
- ☆ *Impedance*
  - *R: 1 Ω to 1 MΩ*
  - *C: 100 pF to 0.1 F*
  - *L: 50 μH to 0.1 H*
- ☆ *Measures equivalents of two-poles R||C, R||L, R+L and R+C*

SOUNDBLASTER, COMPATIBLE & CO.

The measurement software was written for a SoundBlaster 16 VE from Creative Labs. This card features 44-kHz 16-bit stereo sound sampling. The software should also run on 100% SoundBlaster compatible cards, preferably those with the Creative Labs chip set. Regrettably, many low-cost clones use a different chip set, so you are well advised to buy the original SoundBlaster. At a current street price of 70-odd pounds, the SoundBlaster 16 VE is a good investment, and should not 'blast' too large a hole in your hobby budget!

The software, called AF-ANALYSER, is available on diskette through our Readers Service (see page 70). AF-ANALYSER (AFA.EXE) is simple to install. Once you have verified that the diskette you received from us is okay, you start by copying all files on the diskette into a suitably named subdirectory on the hard disk. Next, make sure that the SoundBlaster card is properly configured (address, DMA channel and interrupt – see the README.TXT file).

Start the program from hard disk by typing AFA. It will first attempt to address the sound card. If that fails, an error report is produced. Very likely, your sound card is then improperly configured. Next, the program attempts to secure additional DMA compatible memory offered by the operating system. If that fails as well, another error report is produced. In some cases, you may have to modify your memory set-up. The author uses the analyser system without problems on an 80-MHz 486DX with 4 Mbytes RAM.

Once the initialisation is finished, a picture appears on the monitor, and you are ready to start your first measurement. Incidentally, the software alters the settings of the mixer parameters used on the sound card. The next important point to concentrate on is the wiring between the SoundBlaster card and the measured circuit. The connector pinouts and signal functions are shown in **Fig. 4**. For an initial test, connect the SIGN.-OUT (signal output) socket to a loudspeaker, and start a sweep by pressing the 'x' key on the keyboard. The loudspeaker will produce a signal whose frequency rises.

The measurement system generates its test signals with the aid of the FM sound synthesizer chip on the sound card. The audio power amplifier, which is also contained on the card, allows a peak-to-peak signal level of about 750 mV to be achieved across a load impedance of 8 Ω. In other words, the system is suitable for running checks on loudspeakers at low power levels. The fact that you do not know the absolute level of the signal applied does not distract from the usefulness of the measurement because it makes no difference for the measurement principle used (**Fig. 5**).

The sound card having a stereo A-to-D converter, one channel is used as a reference channel which receives the generator signal directly. The reference channel enables the software to accurately measure the level and the phase of the generator signal. The generator signal is fed through the measured object, for instance, an amplifier or a filter, whose output signal is applied to the other channel on the sound card.

The software uses the signals on the reference channel and the measurement channel to compute the gain or attenuation caused by the measured object, as well as the phase shift. The measurement makes clever use of the A-to-D converter and a phase-sensitive rectifier. A series of individual measurements is performed in the selected frequency range, and the result is displayed on the computer screen in the form of a plotted graph.

The user may view two graphs at a time on the monitor. The parameters shown by the individual graphs are selected via the keyboard. With measurements on amplifiers, for example, it is possible to view the actual value and the phase shift of the measured gain. Similarly, with impedance measurements the real and the imaginary parts may be displayed separately, or the discrete values of an equivalent *RL* combination.

The measurement parameters are easily changed via the keyboard. Likewise, the complete bundle of settings is readily stored on the hard disk. Finally, an *on-line* help function is available, and may be called up at any time to obtain a short description of each available command.

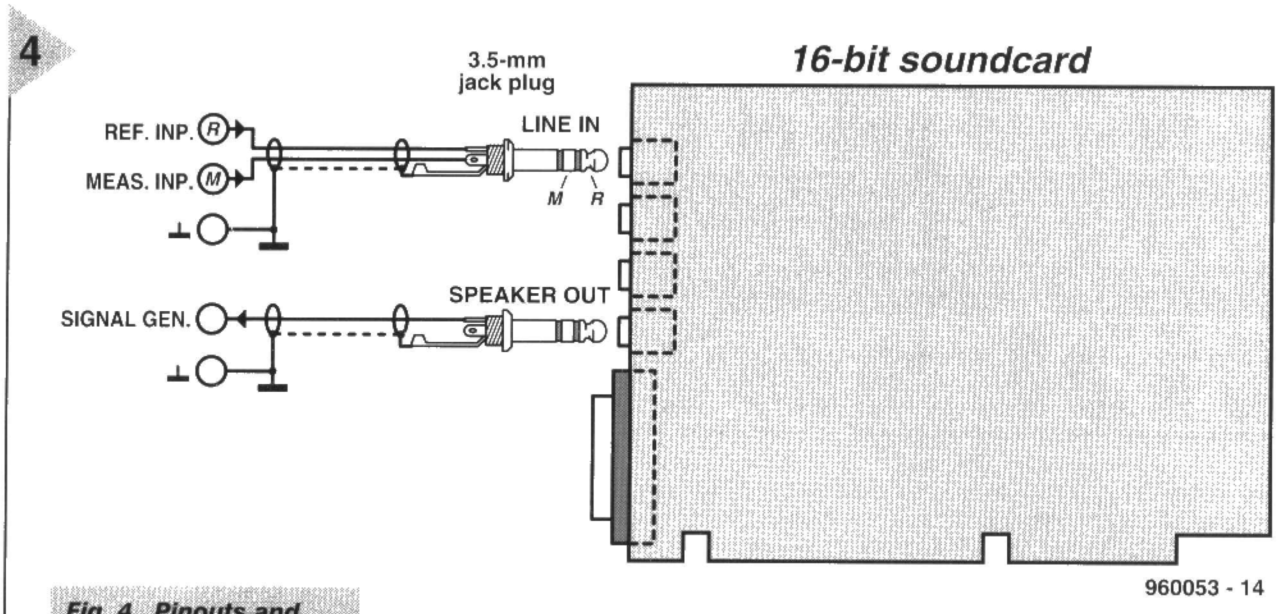


Fig. 4. Pinouts and connecting diagram of the SoundBlaster VE 16 sound card.

YOUR FIRST FREQUENCY RESPONSE MEASUREMENT

As your first measurement object we suggest using an *RC* bandpass filter as shown in **Fig. 6**, connected to the relevant sockets on the SoundBlaster card (Fig. 4). The default parameters used by the measurement software are okay for this initial test. All you have to do is press the **x** key (for execute). That launches the frequency and phase response measurements, the results of which appear on the screen after a while.

After the measurement, the display shows two graphs as illustrated in **Fig. 7**. To enable individual values to be read off accurately, you use the + and – keys to manoeuvre the marker. In this way you capture, for example, f_r at 1,950 Hz, or an attenuation of –9.77 dB at the resonance point. Both values come very close to the theoretical ones.

By pressing the keys corresponding to the letters enclosed in square brackets, it is possible to modify the relevant parameter in the software. That may be necessary at times to improve the way new measurements are matched to given circumstances.

At this point you are ready to do any AF gain and/or phase shift measurement you like. It should be clear by now how the measured object is connected to the sound card. If necessary, an attenuator should be used to prevent overdriving the measured object or the sound card. Circuits with a low-impedance output

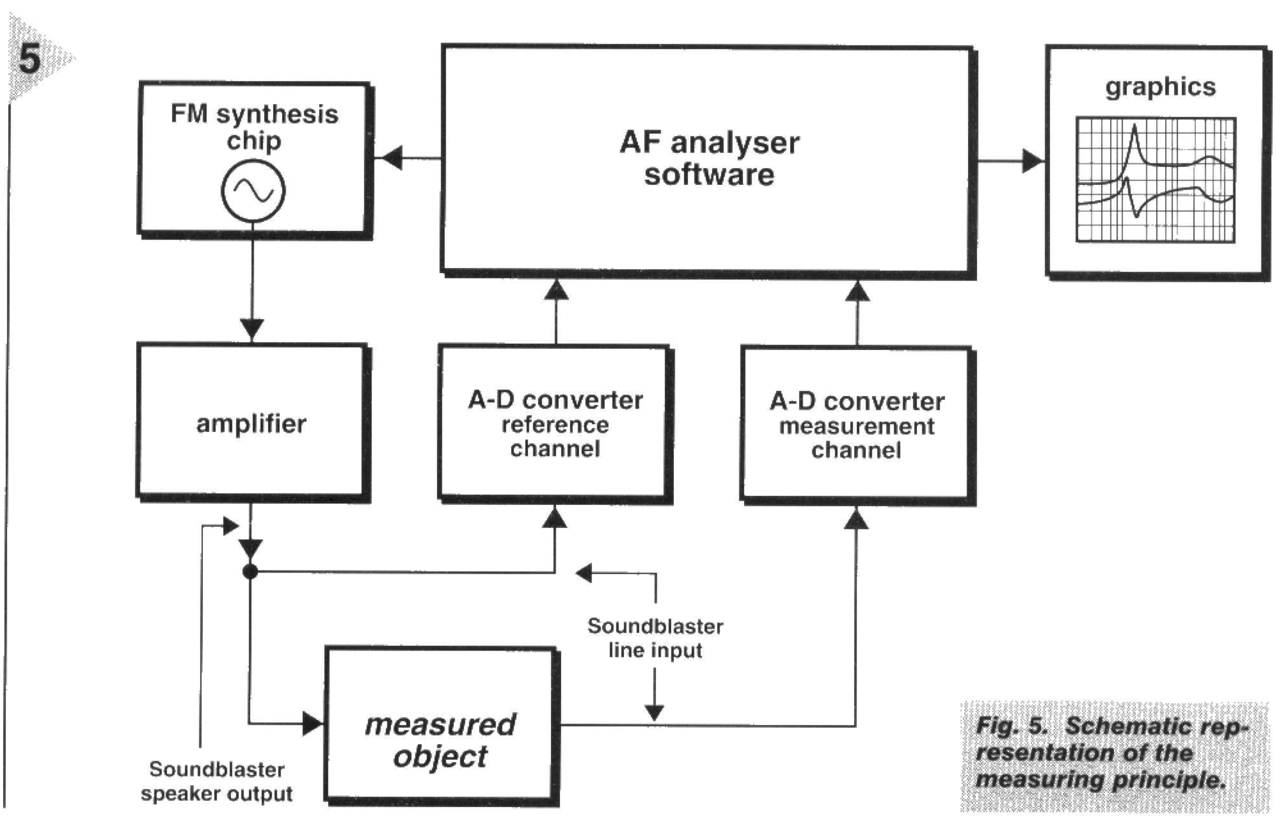


Fig. 5. Schematic representation of the measuring principle.

LIMITS OF THE FREQUENCY RESPONSE MEASUREMENT

No measurement result makes sense if you neglect, or do not know, the limits of the measurement system used. With frequency response measurements, the practical limits of the AF analyser are determined by a number of external conditions, each of which has an effect on the accuracy of the measurement.

Although sudden irregularities like off-scale peaks in the graphical representation of a frequency response curve are sufficient warning that a serious measurement fault exists, it is still useful to be aware of the main problems you may encounter.

- *The first source of trouble may be the FM synthesizer oscillator on the sound card. From about 15 kHz, this oscillator supplies a triangular waveform instead of a sine-wave. This is owing to the fact that the oscillator is of the 'sampling' type. To keep the resulting error as small as possible, certain measures are taken by the software so that only the relevant basic frequency of the signal, not any of the harmonics, is employed for the measurement. None the less, results of measurements above 15 kHz should be taken with a pinch of salt.*

- *Second problem: the A-to-D converters must not be overdriven. Many measurements on amplifiers will therefore require an attenuator pad to be inserted in the measurement channel. If you look at the attenuation graph above the frequency response, it is safe to say that the A-D converter is probably overdriven when levels greater than 0 dB occur, i.e., when the signal level in the measurement channel exceeds that in the reference channel.*

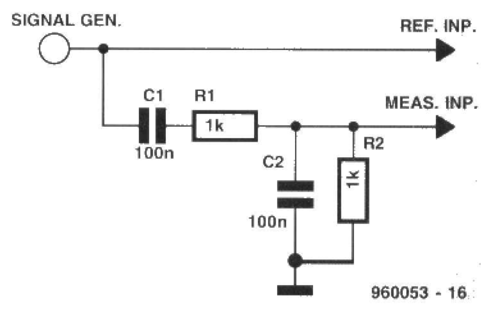
- *Special attention should also be given to the input impedance of the SoundBlaster card. The fact that this input does not have a particularly high impedance should be taken into account when measuring on high-impedance signal sources. If necessary, insert a preamplifier with a high input impedance in the measurement channel. Obviously, the frequency response of this preamplifier may also be checked using the system.*

- *A further limitation to keep in mind is caused by two contending factors: one the one hand, the 16-bit resolution of the sound card, and on the other, the high (electrical) noise level which exists in a PC. Theoretically, a 16-bit converter achieves a signal-to-noise ratio of 95 dB at full drive. In a very 'noisy' environment such as a PC, however, the present analyser system can measure attenuations down to about 70 dB. Not a bad value, mind you, considering that better results are almost impossible to obtain from simple sound cards.*

- *The final sources of interference which must be mentioned here are stray capacitance and resistance, whose effect is especially noticeable with impedance measurement on RF components. More about this phenomenon in next month's concluding instalment.*

Fig. 6. This simple RC bandpass is great for your first measurement with the analyser.

6



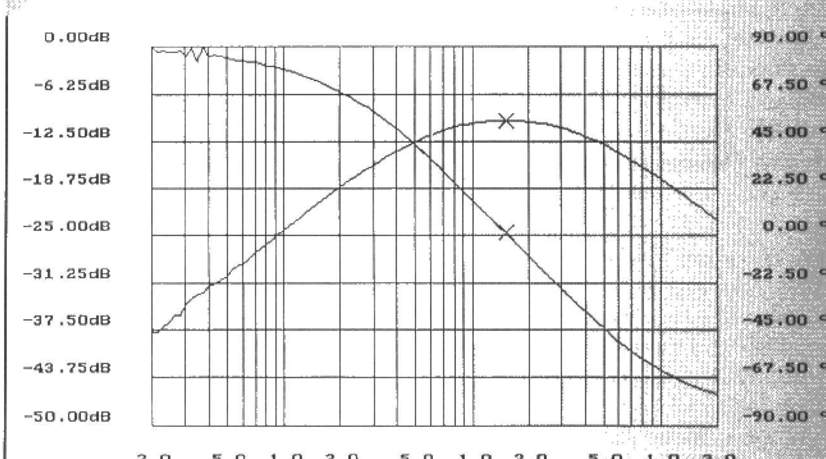
(less than about 10 kΩ) can be measured directly. When a high-impedance output is used (more than 10 kΩ), impedance matching should be provided by a small preamplifier with a high-impedance input.

Next month

Next month's second and last instalment of this article will guide you through the operation of the AF analyser software. We also present a small add-on box for measurements. Don't worry, the box contains only a handful of resistors and a switch. Together with the AF analyser hardware and software, this gives you a fairly advanced impedance measuring instrument. (960053)

Fig. 7. Results of a frequency sweep/phase measurement on the bandpass shown in Fig. 6.

7



electronics on-line

Anyone who is actively involved in electronics and with access to the Internet may use his or her PC to gather information about components, technical software and other interesting products. Via the PC you have almost instant access to information source which are 'hot', up to date and of a staggering size. From time to time, however, the average Internet user has a problem finding exactly those 'sites' which have interesting information. This page in *Elektor Electronics* is a new regular feature in the magazine, intended to inform you about Internet sites that hold *on-line* information which is of interest to electronics enthusiasts like you.

This month we kick off by presenting the www (world-wide web) pages from the USA-based semiconductor manufacturer Harris Semiconductor. The address **http://www.semi.harris.com** stocks a wealth of technical literature in the form of extensive datasheets on components. It is also possible to download related software, and the site contains information about recently released and about-to-be-released Harris components. In practice, this information is much more up-to-date than the ordinary databooks published by Harris. Furthermore, the www site allows you to submit technical queries to the design engineers at Harris Semiconductor.

A totally different Internet site is the one from HiTools Inc., who are also based in the USA. HiTools are suppliers and manufacturers of microprocessor development systems. The www pages found at **http://www.hitex.com** bring you, among others, lots of demo software like an 8051 and an 80166 simulator. A highly interesting option offered by these pages is the link to the so-called *Chip Directory*, which enables you to trace the function and origins of unknown components. The actual search operation is quite simple |s all you have to do is enter the type number of an unknown IC, and the program does the rest. If available in the database, the information appears on your screen after a short while.

A summary of the information at this www site may be found on the *Development Tools CD-ROM*. This CD-ROM contains a number of HTML (HyperText Mark-up Language) files which give the user information on 4,000 chips and 150 manufacturers. The CD-ROM also contains an 8051 and an 80166 simulator, an 80166 debugger and text versions of compilers. A list of *Frequently Asked Questions* (FAQs) about the 8051, 68HC11 and 68k families may help to reduce the complexity of developing applications for these processors. As a matter of course, the *Chip Directory* is also included on the CD-ROM. Although the CD contains an HTML browser, many users will prefer their own web browser like Netscape, Mosaic or Internet Explorer. Fortunately, that is possible! The author of *Chip Directory* is Jaap van Ganswijk who can be contacted at Innovative Design, P.O. Box 3215, NL-2601 DE Delft, The Netherlands, tel. (+31) 15 2132638, fax (+31) 15 2140244.

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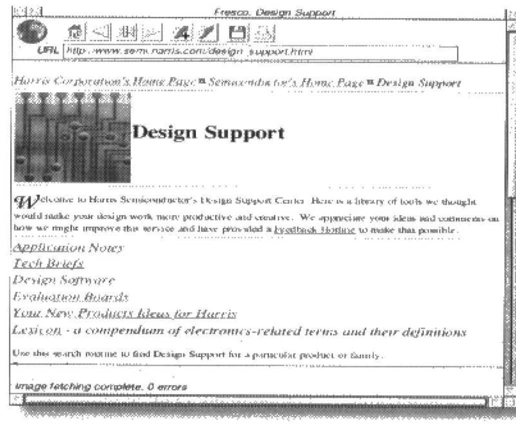
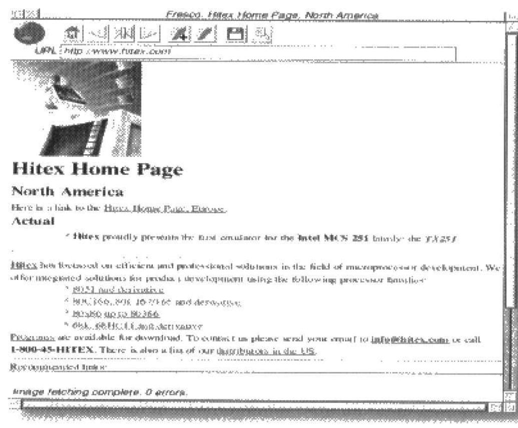
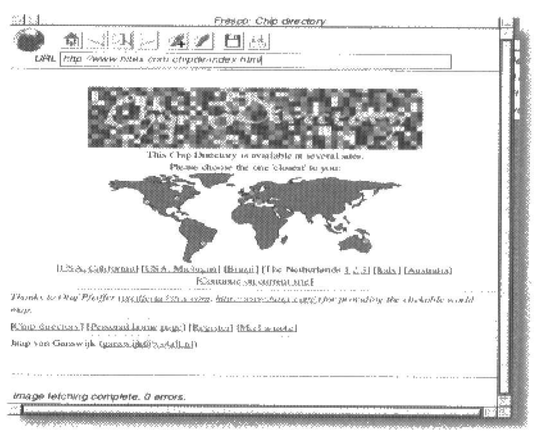
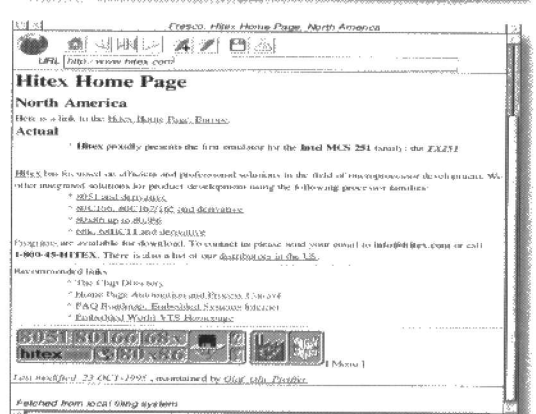








Found a web site which other readers of Elektor Electronics should know about? Let us know the name and URL by telephone, fax or e-mail (elektuur@euronet.nl). If the site is indeed useful and interesting, we'll put it in the limelight using this column.

ADVANCED STOCK CONTROL AND KITTING PROGRAM

For the first time in a market dominated by large expensive accounts-oriented packages, Number One Systems have launched Stockit, a simple uncomplicated stock control program for the real world.

Drawing on the experience of engineering entrepreneurs and design departments already using Number One Systems' range of electronic CAD programs, Stockit is designed to help smaller manufacturers and R&D departments with the day-to-day problems of managing stock.

Stockit is specifically tailored for a small to medium sized production or development environment – it is not an adaptation of a program originally aimed at large-scale manufacturers, accountants or retailers.

Stockit holds complete records of parts lists, stock levels and component suppliers, automatically allocating stock when a new production batch is required. A valuable trial kitting facility allows different production scenarios to be evaluated before a definitive production plan is adopted. The ability to handle fractional quantities allows cable lengths, consumables and labour to be included in the calculations. Stockit even prints enquiry sheets to be sent to suppliers for quotations.

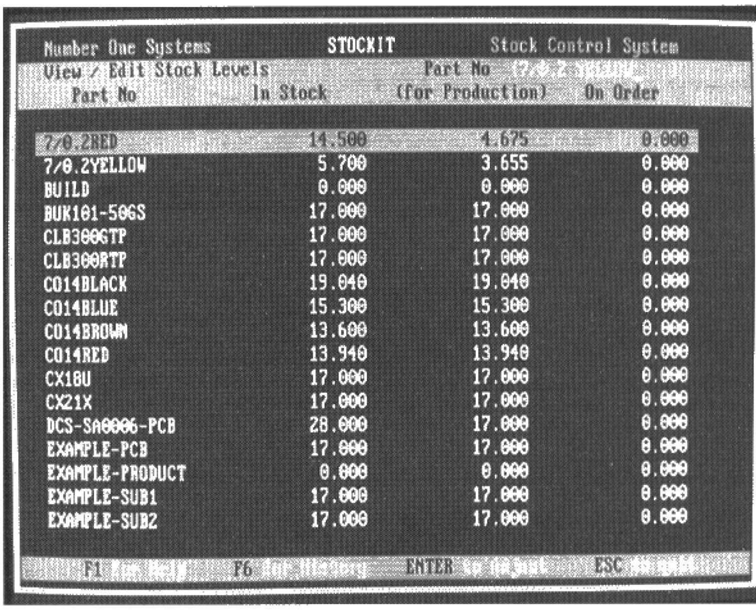
The structure of Stockit enables new users to migrate existing systems gradually, one assembly at a time. The benefits of Stockit can be realised quickly without waiting for every single part to be entered.

By maintaining an up-to-date cost for each part, Stockit makes it simple to determine product manufacturing costs and order values. Stockit can calculate a current stock valuation in a matter of seconds.

While designed with the electronics industry in mind, Stockit is equally applicable to batch manufacture in many other industries.

Priced at just £145.00, Stockit is far easier to use |s and cheaper |s than many accounts-based stock control programs intended for large-scale manufacture.

Number One Systems, Harding Way, Somersham Road, St. Ives, Huntingdon, Cambs PE17 4WR. Tel. (01480) 461778, fax (01480) 494042.



Number One Systems STOCKIT Stock Control System
View / Edit Stock Levels Part No

Part No	In Stock	(For Production)	On Order
7/0.2RED	14.500	4.675	0.000
7/0.2YELLOW	5.700	3.655	0.000
BUILD	0.000	0.000	0.000
BUK101-50GS	17.000	17.000	0.000
CLB300GTP	17.000	17.000	0.000
CLB300RTP	17.000	17.000	0.000
CO14BLACK	19.040	19.040	0.000
CO14BLUE	15.300	15.300	0.000
CO14BROWN	13.600	13.600	0.000
CO14RED	13.940	13.940	0.000
CX18U	17.000	17.000	0.000
CX21X	17.000	17.000	0.000
DCS-SA0006-PCB	28.000	17.000	0.000
EXAMPLE-PCB	17.000	17.000	0.000
EXAMPLE-PRODUCT	0.000	0.000	0.000
EXAMPLE-SUB1	17.000	17.000	0.000
EXAMPLE-SUB2	17.000	17.000	0.000

F1 F6 ENTER ESC

DOUBLE-SPEED CD-ROM DOUBLES AS PERSONAL AUDIO CD PLAYER

Portable Add-ons recently introduced the launch of CD_Mobile, an external double-speed CD-ROM drive and Type-II PC Card Interface designed for notebook computers. With four unique power options (computer, mains, standard, or rechargeable AA batteries) the CD Mobile gives total flexibility of use. Since the CD_Mobile can be battery-powered, it can be used anywhere, making it a truly portable solution.

At a retail price of £299, CD_Mobile is an inexpensive way of adding CD-ROM functionality to existing notebooks. The few notebooks with a CD_ROM drive built-in tend to be prohibitively expensive for most users. Since an internal drive always draws current, it will place a load on the machine's battery; in addition, a built-in CD-ROM drive adds to a notebook's bulk. As the CD_Mobile is a separate unit, it can be unplugged and the PC Card Interface removed when not in use, reducing both power consumption and weight. The CD_Mobile can easily be shared amongst a group of users. The IDE-based interface is, as with all good PC Cards, fully host-swappable.

The CD_Mobile's CD-ROM drive is fully MPC2 compliant. It also supports Video_CD and CD-i in addition to CD-ROM modes_1 and 2, audio CDs, multi-session Photo_CD, and CD-XA.

The beautifully styled CD_Mobile has a full control panel and a multi-function LCD screen. The unit can be used as a superb-quality personal CD player, allowing you to listen to your favourite album while compiling a spread-sheet on the train. The CD-Mobile may also be used with recent in-car stereo systems that feature a line input, or any cassette/radio if a commonly available adaptor is used.

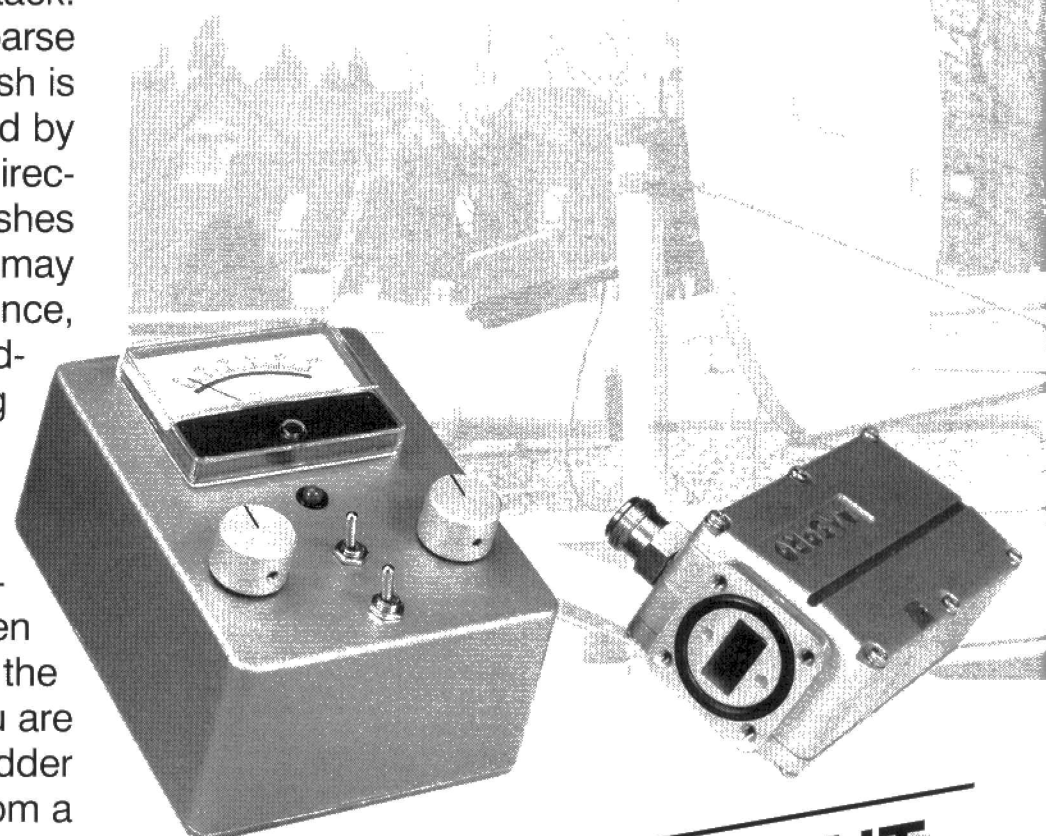
Portable Add-Ons (UK) Ltd., Surrey Technology Centre, 40 Occam Road, Guildford GU2 5YH. Tel. (01483) 440777, fax (01483) 452304, e-mail: cbrooks@portable.co.uk.

satellite finder

DISH ADJUSTMENT MADE EASY

Adjusting a satellite TV dish is often compared to finding a needle in a haystack. Although the coarse setting of the dish is fairly easy to find by looking at the direction of nearby dishes in the street, you may need a lot of patience, mechanical twiddling and shouting to and from the TV room before the first pictures appear. The problems are often aggravated by the fact that you are standing on a ladder or 'dangling' from a balcony. The instrument described here is simply connected to the LNC output, and does away with the need to actually see the received picture. All you have to do is watch the needle of a moving-coil meter, and peak the dish adjustments for the highest reading. Battery-powered and portable!

Design by Christian Denolle, F1FAU



Despite the advice given by dish installers to seek professional help when it comes to mounting and adjusting the 'outdoor parts' of your newly purchased satellite TV kit, it is great fun, and instructive, too, to tackle the matter yourself. The dishes for today's most popular TV satellites, Eutelsat and Astra, have a diameter between 50 and 80 cm, and are relatively easy to install yourself. In the past, dishes were much larger and, consequently, much more difficult to erect and point at the satellite. The technological advances made in LNC design and construction have brought satellite TV reception to the masses because they have allowed dished to become smaller for the same quality of reception.

THE VARIABLES

Getting tuned to those exciting satellite TV channels is all a matter of eliminating unknown variables. To prove the general concept that 0.1% information is 'somewhere', hidden in 99.9% noise, let's draw up a (worst-case) list of things we do **not** know when we unpack the box.

Q1. Receiver tuning: you may be at 'any' frequency between 950 MHz

and 2,000 MHz, or at 'any' of up to 250 channels.
Q2. LNC polarization: this may horizontal, vertical, left-hand or right-hand circular.
Q3. LNC band selection: you don't know in which band you are (Eutelsat/Astra/Astra-1D/DBS/Telecom).
Q4. Re-modulator tuning: what are you actually receiving on your TV set? Note: this is not a problem if you are using a SCART link between the receiver and the TV.
Q5. Dish position, horizontal plane ('azimuth'): the theoretical range is 180°!
Q6. Dish position, vertical ('elevation'): the theoretical range is 90°!

Now, that looks pretty daunting. So, let's eliminate the variables one by one. The first three points are easily solved by consulting satellite channel overviews which are published monthly by specialized magazines such as *What Satellite*, and matching the information given with that presented in the user manual that came with your receiver.

A1. Most receivers these days come pre-tuned to Astra, Eutelsat and HotBird channels. If not, make sure you understand the tuning system, and calculate the receiver tuning frequency.
A2. Make sure you know the polarization of the station ('transponder') you wish to receive.
A3. The same for the LNC band selection.
A4. Switch the satellite TV receiver off and on to make sure you have the receiver's output signal (noise, probably) on your TV screen. Note that FM noise (as supplied by the receiver) is a little coarser or 'grainier' than AM noise which is normally produced by your TV set.
A5 and A6. These two variables are part and parcel of the outdoor unit, at least, if you have a fixed-dish system. Adjusting a motorized dish with a polar-mount actuator is best left to the professional installer. Like the LNC band selection, the tuning frequency and the polarization, the angles for azimuth and elevation for your location (**Fig. 1**) may be found in published tables. In the UK, the elevation will be between 22° in the far North and about 30° in the South. There are also excellent computer programs around which do perfect az/el calculations for any location on the globe.

1

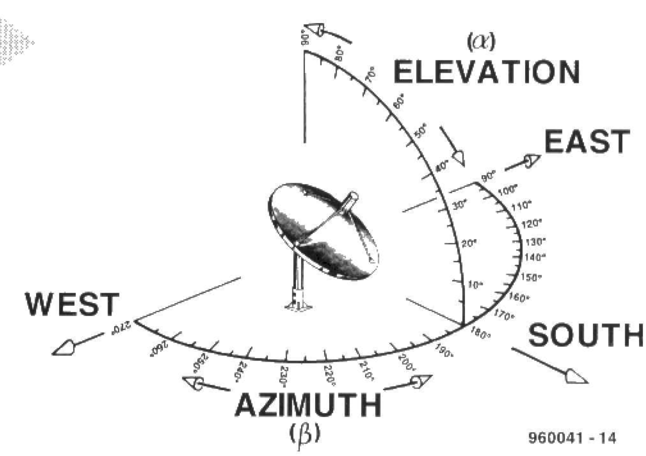


Fig. 1. A satellite TV dish has two angles to set: azimuth (horizontal plane) and elevation (vertical plane).

Hitting the beam

Assuming that your receiver and TV are set properly, a big problem still exists in the fact that you can't see the TV screen from where you are on the roof or balcony. So you need a helper and/or a pair of walkie-talkies. If neither is available, the only solution is to drag the TV screen within sight. Apart from the obvious problems and perils caused by hauling even a portable TV set and a compact sat receiver on to the roof, this solution will not necessarily give the best results.

When you first hit upon the beam transmitted by the satellite, the effect on the TV screen is very sudden and switch-like, quite unlike the more gradual effect you may be accustomed to from tuning to terrestrial television stations. The suddenness is caused by two factors: (1) the use of FM modulation and (2) the small pointing angle of the dish. Once the signal strength exceeds the so-called FM detection threshold, the TV signal changes suddenly from almost invisible to crisp and clear. The same with the dish angle: change it a little and you lose the picture almost instantly, although some 'sparklies' may appear if the signal strength is just above the threshold (7 to 9 dB S/N). Unfortunately, the fact that the picture is free from sparklies does not mean that you have hit upon the right dish position. You may become painfully aware of this during heavy rain or snowfall, when sparklies appear, and it's not Star Trek or the latest computer animation on the screen!

Signal strength

Although the quality of the received picture is fine for an initial adjustment of the dish, you should not miss out on those few extra dBs which are necessary to prevent sparklies under adverse weather conditions. The only way to squeeze out these dBs from the system is to judge the signal strength with a dedicated meter rather than the TV set or monitor. Peaking the dish adjustments for the highest signal strength as indicated by a meter will give you the best possible reception, and some headroom in case of adverse weather conditions. Some satellite TV receivers do offer a signal strength meter function, but it is difficult to use in most cases, being aimed at the professional installer. Alternatively, the signal strength may be indicated by an on-screen horizontal bar, accessible through the setup menu. Unfortunately, that's fancy stuff, and not much use either if you can't see the TV screen from the roof!

All in hand

The present instrument consists basically of a two-stage high-gain amplifier and a signal rectifier. The input of the amplifier is connected to the LNC via a short length of coax cable. The signal strength is indicated on a classic moving coil meter.

The circuit diagram of the Satellite Finder is shown in **Fig.1**. Let's first look at the power supply. The circuit and the LNC are powered by a pack of four series-connected 4.5-volt batteries. The 18-V battery voltage is fed to the LNC via switches S1, S2 and choke L1. Most, if not all, currently available LNCs are capable of operating at 18V. Whether that voltage selects horizontal, vertical, right-hand or left-hand circular polarization in the LNC is largely immaterial because most satellites transmit enough signals in one polarisation plane for the tester to detect and respond to. Do make sure, however, that the LNC receives the desired band at 18V. Note that switch S1 must remain closed in the

2

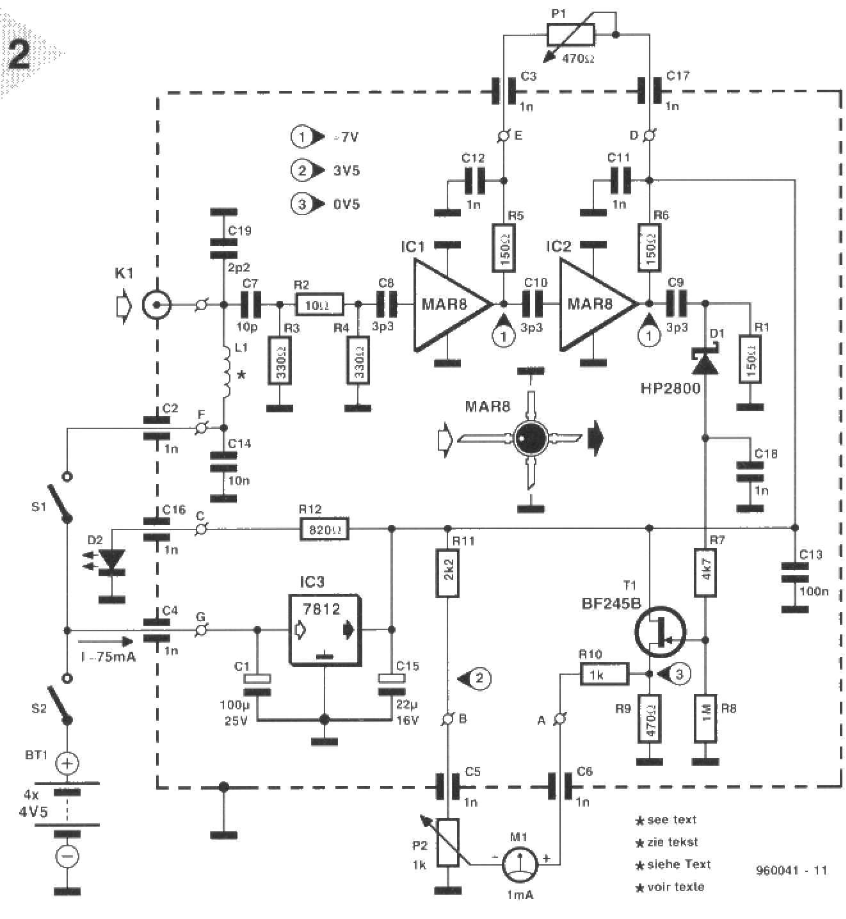


Fig. 2. Circuit diagram of the Satellite Finder. The crucial elements are two MAR8 drop-in gigahertz amplifier ICs from MCL.

(rare) case of an LNB which is not powered via its coax output.

The battery pack voltage also arrives at the input of a voltage regulator, IC3, which supplies a stable 12-V rail for the amplifier blocks, IC1 and IC2, and the logarithmic meter driver, T1. Current consumption of the circuit is only about 75 mA. Depending on its make, the LNC may draw anything between 100 mA and 500 mA. An LED, D2, is used as an on/off indicator on the instrument.

The output spectrum of most LNCs extends from 800 MHz to about 2,000 MHz. The signal levels are generally high, given that most LNCs have a conversion gain in excess of 60 dB. That is still not enough, however, to enable a simple (passive) rectifier to be used in combination with a moving-coil meter. Hence, more gain is required, for which IC1 and IC2 are responsible. Each of the type MAR8 monolithic drop-in amplifiers supplies a solid 15 to 20 dB of gain. The MARs are cascaded, and operated at their typical supply voltage of about 7 V, which is applied via series resistors R5 and R6. Note that the supply voltage of IC1 is adjustable with pot P1. That is done to enable the gain of the first amplifier to be reduced within a reasonable range to prevent overloading of the meter circuit.

It should be noted that the MAR-8, unlike its family members, has an input and output impedance which is higher than 50Ω. The actual value depends on the frequency. Fortunately, that is not a problem here because of the high signal levels, and because the there is plenty of gain to compensate small mismatches. Low noise is not a point, either! More on MAR amplifiers may be found in the inset and in the Reference at the end of this article.

The rectifier is formed by a Schottky diode, D1. If difficult to obtain, the HP2800 may be replaced by a lower-spec type such as the BAT82.

The meter driver is conventional and based on a FET (T1) which ensures a partly logarithmic meter response. The meter is nulled with pot P2. Absolute readings are not in order, so a scale is not really necessary on the meter. All we are after is a well-defined peak in the meter reading, and that's exactly what the circuit will give you, provided you are able to point the dish at the satellite.

Building it

The Satellite Finder is best built on a small printed circuit board of which the design is shown in **Fig. 3**. Because the board is not available ready-made through the Readers services, you will have to make it yourself, or have it made. The board is double-sided, but not through-plated. The top side of the board acts as a ground plane.

It's a wonderful fact that this circuit has no adjustable inductors or esoteric parts to contend with, although it operates in the gigahertz frequency range. The only inductor in the circuit is a small choke, L1, which consists of three turns of 0.3-mm dia (30SWG) enamelled copper wire (e.c.w.) through a 3-mm long ferrite bead – see **Fig. 4**. The only 'problem' with the MARs is that they are, well, tiny!

The MARs are fitted **at the underside of the board. Check the orientation: the dot on the device marks the RF input.** The two electrolytic capacitors, C1 and C15, are mounted about 2 mm above the board surface to enable their negative terminals to be soldered to the copper ground plane at the top side of the board.

For proper screening, the completed board must be fitted in a small metal case. The case is best made from a 30-mm wide strip of tin plate which is bent around the board edges (see photographs). Do not solder the seam before you have determined the position of the feedthrough capacitors which are fitted in one of the side panels. The solder eye of the feedthrough capacitor should be at the outside of the case. The collar is soldered all around to the side panel using a medium-power sodlering iron. Depending on what you have available, the RF input socket, K1, is either a 'BNC' (flange) type or an 'F' socket. Although the latter is cheaper, it may be more difficult to get hold of. It is also less suitable for frequent connection and disconnection, so we really recommend using a BNC socket. You will also need to make a short coax cable to connect

the tester to the LNC. This cable has an F plug at the LNC side, and a BNC plug at the side of the tester. The flange of the BNC socket is either soldered or screwed to the tin-plate panel, and the centre pin is soldered directly on to the RF input pad on the board. If necessary, remove the PTFE collar around the centre pin with a sharp knife.

The completed tin-plate case is built into a diecast enclosure (which may also contain the battery pack). The front panel holds the moving-coil meter, the two LEDs and the controls (two pots and two switches). The controls are connected to the respective feedthrough capacitors via short wires. If an external battery pack is used, it is connected to the tester via a low-voltage d.c. adaptor plug and socket.

Practical use

Easy, as far as the tester is concerned! Connect the tester to the LNC with the home-made cable. Flick the two switches, the LED should light. The meter may show some indication already. Check that the indication varies if you turn pot P1. Null the meter by turning pot P2 with the LNC switched off (S1).

The meter needle will show a marked peak if you hit upon the satellite beam. Once you have found the initial dish position, reduce the gain by turning P2, and then adjust the dish again. In this way, you will be able to obtain the best possible results from your outdoor unit. (960041)

Reference:

'Using the MAR-x series of very wideband monolithic microwave integrated circuits (MMICs)', by Joseph Carr. *Elektor Electronics* October 1992.

3

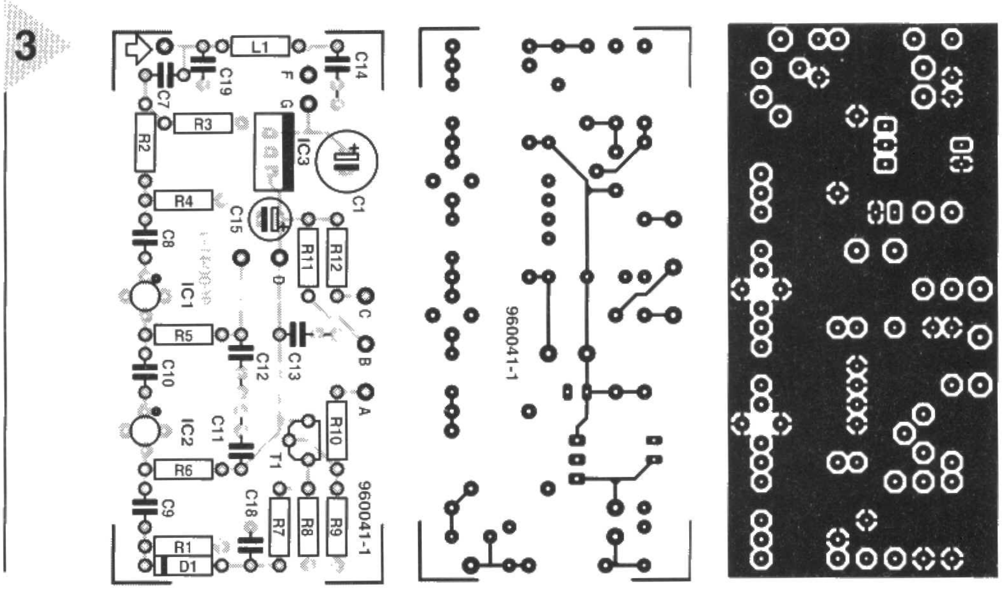


Fig. 3. Printed circuit board design (board not available ready-made through the Readers Services).

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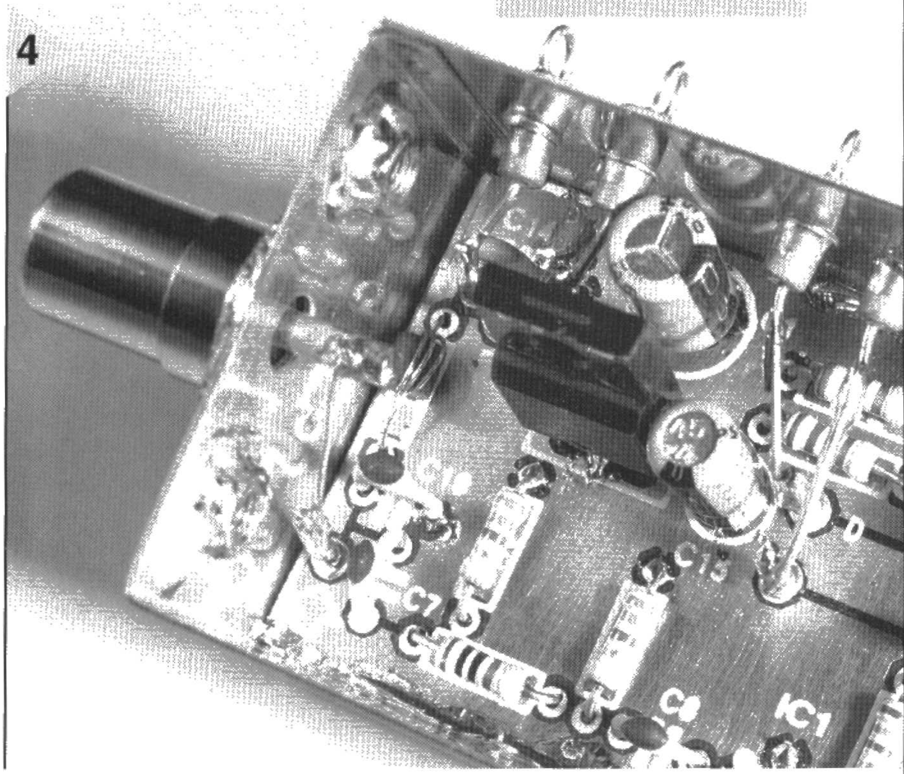


Fig. 4. A close look at the prototype of the satellite finder. Notice the feedthrough capacitors and the small ferrite bead.

COMPONENTS LIST

Resistors:
R1,R5,R6 = 150Ω
R2 = 10Ω
R3,R4 = 330Ω
R7 = 4kΩ7
R8 = 1MΩ
R9 = 470Ω
R10 = 1k
R11 = 2kΩ2
R12 = 820Ω
P1 = 470Ω potentiometer
P2 = 1kΩ potentiometer

Capacitors:
C1 = 100μF 25V radial
C2-C6,C16,C17 = feedthrough capacitor 1nF
C11,C12,C18 = 1nF
C7 = 10pF
C8,C9,C10 = 3pF3
C13 = 100nF
C14 = 10nF
C15 = 22μF 25V radial
C19 = 2pF2

Inductor:
L1 = 3 turns 0.3mm dia. e.c.w. on 3mm ferrite bead

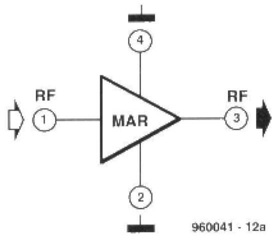
Semiconductors:
D1 = HP2800 or other RF Schottky diode (e.g. BAT82)
D2 = LED
T1 = BF245B
IC1,IC2 = MAR8 (Mini Circuits Laboratories)
IC3 = 7812

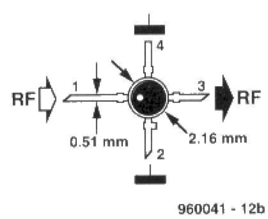
Miscellaneous:
K1 = antenna socket (with flange) (see text)
S1,S2 = on/off switch.
BT1 = four 4.5V batteries
M1 = moving coil meter, 1mA f.s.d.

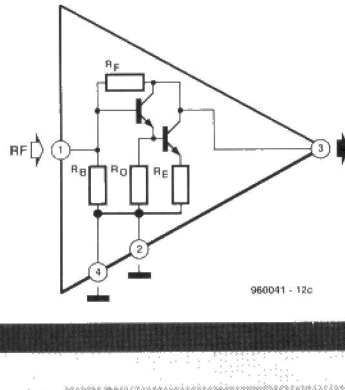
reMARkable wideband RF amplifiers

MAR devices from Mini Circuit Laboratories are remarkable because they make RF amplifier design accessible to anyone. MARs are cheap, easy to use and pretty fault-tolerant. These wonderful four-pin devices match 50-Ω input and output impedances without external impedance transformation circuitry (which is normally a nightmare to beginners). They are basically silicon bipolar monolithic ICs in a two-transistor Darlington configuration, internally laid out for ultra-low stray inductance and capacitance. Depending on the exact type, the overall gain of these devices is typically 13 to 33 dB between d.c. and about 2 GHz (yes!). Some types are optimized for low noise, others, like the MAR8, for very high gain.

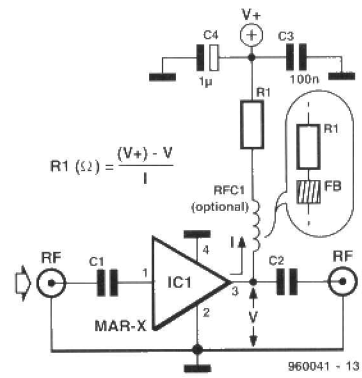
In the basic circuit for a wideband amplifier based on a MARx device, the RF IN and RF OUT terminals are protected against d.c. by coupling capacitors C1 and C2. Also traditional is the supply decoupling consisting of a tantalum electrolytic capacitor (C4) and a ceramic 100-nF type (C3). The amplifier is powered via a series resistor which determines the operating voltage, as shown by the formula. The operating current for the device used may be found in the datasheets, and will be of the order of 40 to 80 mA.



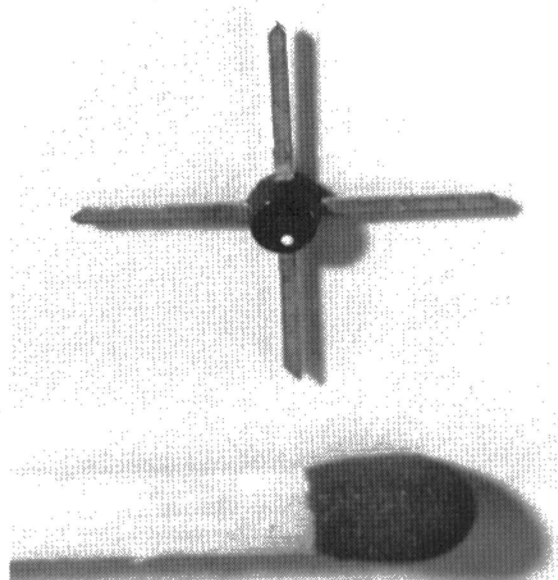




Internal schematic of MAR amplifier, circuit symbol and device package.



Generic MAR-x circuit.



Manufacterer: SGS-Thomson

The TDA7330 is an RDS (Radio Data System) demodulator. The IC includes a 57-kHz switched capacitor input band pass filter, a bit rate clock recovery circuit, DSB demodulator circuit, bi-phase PSK decoder, differential decoding circuits, ARI identification and signal quality outputs. The data and clock output signals (RDDA, RDCL) can be processed further by a suitable microprocessor.

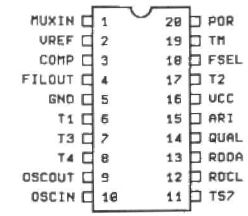
Absolute maximum ratings:

Supply Voltage: 7 V
Operating Temperature Range: −40 to +85°C

Features:

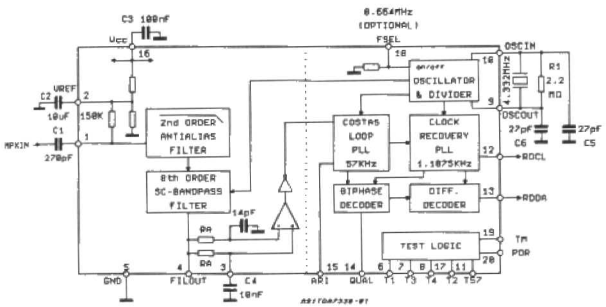
- High-performance, stable 57-kHz filter
- Adjustment-free filter, no external components
- RDS demodulation without external components
- ARI output (SQ indication)
- RDS signal quality output
- 4.332-MHz quartz crystal oscillator (8.8664-MHz optional)
- Low-noise mixed bipolar/CMOS technology

Pin Connection



Pin	Name	Description
1	MUXIN	RDS input signal
2	V_{REF}	Reference voltage
3	COMP	Non-inverting comparator input (smoothing filter)
4	FIL OUT	Filter output
5	GND	Ground
6	T1	Test output (not used)
7	T3	Test output (not used)
8	T4	Test output (not used)
9	OSC OUT	Oscillator output
10	OSC IN	Oscillator input
11	T57	Test output (not used)
12	RDCL	RDS clock output
13	RDDA	RDS data output
14	QUAL	Signal quality output (high = good)
15	ARI	Output for ARI indication (high = RDS + ARI or ARI only, low = RDS only, undefined when no signal present)
16	V_{CC}	Supply voltage
17	T2	Test output (not used)
18	FSEL	Frequency selector pin
19	TM	Test mode pin (open = normal run, closed to VCC = Test mode)
20	POR	Reset input for testing (active high)

Block Diagram



RF Amplifiers

Manufacturer: Mini-Circuits

Mini-Circuits

The MAR-cascadable amplifier series is a family of silicon bipolar monolithic integrated circuits fabricated with nitride self-alignment, ion implantation for precise control of doping and passivisation to achieve high reliability. These devices, priced from below one dollar in volume quantity, exhibit excellent unit-to-unit uniformity and are ideally suited as 50-ohm amplifier building blocks. The MAR devices are simple to use if the proper board layout is used, along with proper grounding, biasing and steps to minimize parasitics.

Mini Circuits, P.O. Box 350166, Brooklyn, New York 11235-003.

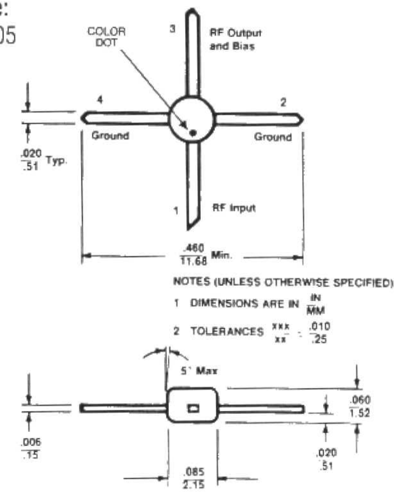
Applications:

- Low-power transmitter
- Boost signal for improved detector efficiency
- Multi-stage amplifier chain
- Buffer amplifier for oscillators
- Isolator

Features:

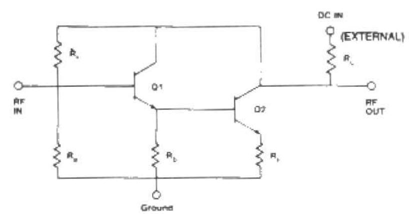
- Easy to use, 50-Ω input/output
- Smooth response over the band, no external resonances
- Easy for printed-circuit designs, one input and one output
- Can operate as low as 5 Vdc
- Low impedance, less susceptible to EMI

Case:
VV105



Pin Functions:		
Pin	**Name**	**Function**
1	RF IN	RF input
2	GND	Ground
3	RF OUT	RF output and bias
4	GND	Ground

Internal Schematic:



RF Amplifiers MAR-x

RF and Video

ELEKTOR ELECTRONICS DATASHEET 03/96

Electrical Characteristics:

Model No.	Color Dot	Max. Freq. [GHz]	Typ. Gain [dB] 100	500	1000	2000	Min	Max. Power, dBm Output (1dB) Compression	Input (no damage)
MAR-1	brown	1	18.5	17.5	15.5	-	10.0	0	+10
MAR-2	red	2	13	12.8	12.5	11	8.5	+3	+15
MAR-3	orange	2	13	12.8	12.5	10.5	8.0	+8	+15
MAR-4	yellow	1	8.2	8.2	8.0	-	7.0	+11	+15
MAR-6	white	2	20	19	16	11	9	0	+15
MAR-7	violet	2	13.5	13.1	12.5	10.5	8.5	+4	+15
MAR-8	blue	1	33	28	23	-	19	+10	+15

	Dynamic Range Intercept pt. [dBm] NF [dB] typ.	3rd order typ.	VSWR In	Out	Max. Rating at 25 °C I [mA]	P [mW]	DC power at Pin 3 I[mA]	U [V]
MAR-1	5.0	15	1.5:1	1.5:1	40	100	17	5
MAR-2	6.5	18	1.3:1	1.6:1	60	325	25	5
MAR-3	6.0	23	1.6:1	1.6:1	70	400	35	5
MAR-4	7.0	27	1.9:1	2:1	85	500	50	5
MAR-6	2.8	15	2:1	1.8:1	50	200	16	3.5
MAR-7	5.0	20	2:1	1.5:1	60	275	22	4
MAR-8	3.5	27	3:1	3:1	65	500	36	7.5

Amplifier	Bias Current I_B [mA]	Bias Voltage $+V_0$	R_C (approx.) +5 V	+9 V	+12 V	+15 V
MAR-1	17	~5	–	235	412	588
MAR-2	25	~5	–	160	280	400
MAR-3	35	~5	–	114	200	286
MAR-4	50	~6	–	60	120	180
MAR-6	16	~3.5	98	344	531	719
MAR-7	22	~4	45	227	364	500
MAR-8	36	~8	–	–	111	194

Calculation of R_C:

$R_C = (V_{CC} - V_d) / I_d$ [Ω]

where

V_{CC}: Supply voltage applied to R_C [V]

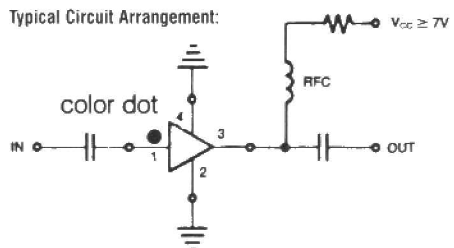
V_d: Voltage at the supply terminal of the MMIC [V]

I_d: Quiescent bias current [A]

The dissipation of R_C is given by

$P_{diss} = I_d^2 \cdot R_C$ [Ω]

Typical Circuit Arrangement:



RDS Demodulator + Filter TDA7330

RF and Video

ELEKTOR ELECTRONICS DATASHEET 03/96

Electrical characteristics :

(V_{CC} = 5 V, T_{amb} = 25 °C, f_{osc} = 4.332 MHz, V_{IN} = 20 mV_{rms}, unless otherwise specified)

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
Supply						
V_{CC}	Supply Voltage		4.5	5	5.5	V
I_S	Supply Current			9		mA
Filter						
F_C	Centre Frequency		56.5	57	57.5	kHz
BW	3-dB Bandwith		2.5	3	3.5	kHz
G	Gain	f = 57 kHz	18	20	22	dB
A	Attenuation	Δf = ± 4 kHz f = 38 kHz, V_i = 500 mV_{rms} f = 67 kHz, V_i = 250 mV_{rms}	18 50 35	22 80 50		dB
ΔPh	Phase non-linearity	A* B* C*		0,5 1 2	5 7.5 10	DEG
R_i	Input Impedance		100	160	200	kΩ
S/N	Signal to Noise Ratio	v_i = 3 mV_{rms}	30	40		dB
V_i	Input Signal	f = 19 kHz, T3 ≤ 40 dB** f = 57 kHz (RDS + ARI)			1 50	V_{rms} mV_{rms}
R_L	Load Impedance	Pin 4	100			kΩ
Limiter						
RA	Resistance Pin 3-4		15	21	28	kΩ
Oscillator						
F_{OSC}	Oscillator Frequency	F_{SEL} = Open (internal 40-kΩ-Pull-down-Resistor, with 4.332-MHz-Quarz) F_{SEL} = to V_{CC} (with 8.664-MHz-Quarz)		4.332 8.664		MHz
Demodulator						
S_{RDS}	RDS Detection Sensitivity		1			mV_{rms}
S_{ARI}	ARI Detection Sensitivity		3			mV_{rms}
T_{lock}	RDS Lock time			100		ms
V_{OH}	Output HIGH Voltage	I_L = 0.5 mA	4			V
V_{OL}	Output LOW Voltage	I_L = 0.5 mA			1	V
f_{RDS}	Data Rate for RDS			1187.5		Hz

*: The phase non-linearity is defined as ΔPh = |−2Φf2 + Φf1 + Φf3|, where Φfx is the output-input phase difference at the frequency fx (x = 1, 2, 3).

Measurement	f1 (kHz)	f2 (kHz)	f3 (kHz)	ΔPh max.
A	56.5	57	57.5	<5°
B	56	57	58	<7.5°
C	55.5	57	58.5	<10°

**: The 3rd harmonic (57 KHz) must be less than −40 dB with respect to input signal plus gain.

surround-sound subwoofer part 1

Most surround-sound installations use loudspeaker boxes of modest dimensions so as to avoid making them too obtrusive for the usual living room. The consequence of this is a limited bass response, whereas especially the low frequencies can provide impressive effects with a good surround-sound system. To counter this drawback, the bass response can be enhanced with the subwoofer described in this three-part article.

Design by T. Giesberts

Surround sound, the popular audio craze of the past few years, can provide an impressive combination of sound and picture when it is used in conjunction with a TV set. Good-quality spatial sound is provided by a number of loudspeakers (usually five) located in front of and behind the listener(s). Five loudspeakers present a problem, of course, in that they take up a lot of space in the average living room. To keep the space occupied by them to a minimum, the loudspeakers are often fairly small. Moreover, in economy-price systems, cost is important, too, and this also tends to keep the boxes small.

Unfortunately, small loudspeaker boxes are detrimental to good bass reproduction. On the surface, this may not seem such a terrible thing in an audio-visual system until it is realized that the low frequencies contain spatial information. Moreover, we perceive low frequencies not only via our ears, but also through our entire body and this causes good low-frequency reproduction to give that added feeling of reality to the sound. All this makes it clear that the importance of low frequencies must not be underestimated.

The reproduction of low frequencies requires the displacement of large volumes of air. This in turn means that a large low-frequency drive unit (woofer) should be used. But such a unit must be contained in a large enclosure to enable it to reproduce low frequencies effectively. And this is where the crux of the matter is: most living rooms just do not have the space for such a large box.

In the subwoofer described in this article an attempt has been made to find a compromise between the contradictory requirements just outlined. It uses a large (300 mm) drive unit

Technical data

Drive unit	*300 mm (8 in), e.g. Monacor (SPH-300TC); KEF; Radio Shack (40-1024); Parts Express (295-240)*
Dimensions of box	*660×406×420 mm (26×16×16 9/16 in) incl. legs*
Volume of box	*about 65 l net*
Type of box	*bass reflex*
Nominal impedance	*8 Ω per channel*
Efficiency	*88 dB W^{-1} m^{-1}*
Frequency range	*45–105 Hz*
Loading	*max 250 W per channel*

housed in a modestly-sized enclosure of 65 l. The enclosure is designed in the form of a side table with the drive unit fitted between the legs so as to make it (virtually) invisible. The volume of the enclosure is not really large enough for very low frequency reproduction, but a solution for this will be published in next month's instalment. This consists of an active correction network and associated amplifier that bring the –3 dB point down to 20 Hz. This article describes the passive version of the subwoofer which can be used without any difficulties with existing apparatus. Its frequency range extends from about 45 Hz to 105 Hz. The upper frequency and the efficiency of the unit provide a good match with the (smaller) front loudspeakers.

Although so far reference has been made only to a surround-sound system, the subwoofer may, of course, also be used with a standard stereo sound system.

THE (PASSIVE) DESIGN

The design is based on a 300 mm (8 in) Monacor SPH-300TC drive unit, but other makes, such as KEF, Radio Shack (40-1024), or Parts Express (295-240) should give good performance as well. The SPH-300TC is a relatively inexpensive unit with a fairly large magnet that displaces a volume of around 0.2 l. Its parameters make it suitable for use in a bass reflex enclosure.

If the loudspeaker is to be used with a stereo system, it should have connections for both channels. This means that either two drive units or a drive unit with dual voice coil should be used. Each voice coil is connected to one of the channels via a suitable filter. The present design uses the latter solution, since the use of two drive units would make the box unnecessarily large.

The alignment of the enclosure is determined with the simulation program Boxcalc, and aims to arrive at a compromise between a (relatively) small volume and a low –3 dB point. This results in a 65 l box with the pipe (acoustical resonator) tuned to 23 Hz. The overall frequency response is shown in **Fig. 1**. The –3 dB point is at 45 Hz, which, considering the small box volume, is pretty good. The –3 dB point is low enough to allow the subwoofer to be used as a passive unit with most existing systems.

1

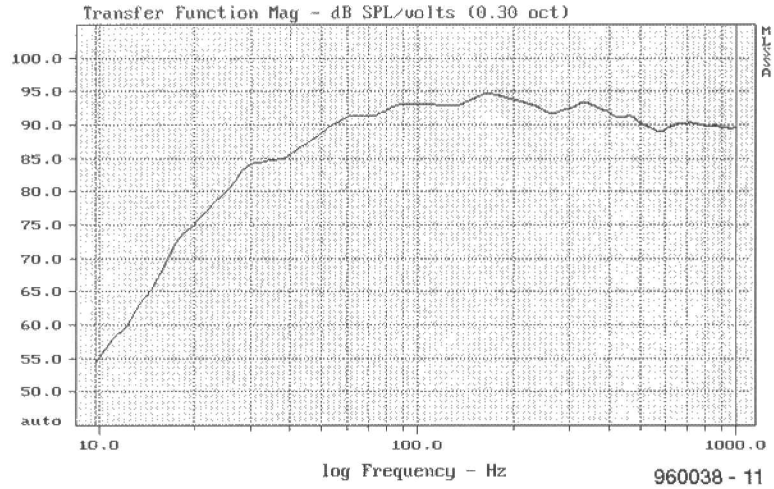


Fig. 1. The frequency response curve of the SPH-300TC in a 65 l bass reflex enclosure tuned to 23 Hz.

THE FILTER

Since the design aims at keeping the costs as low as feasible, the (passive) filter has been kept as simple as possible, which, in the case of a subwoofer, is not as easy as it may seem.

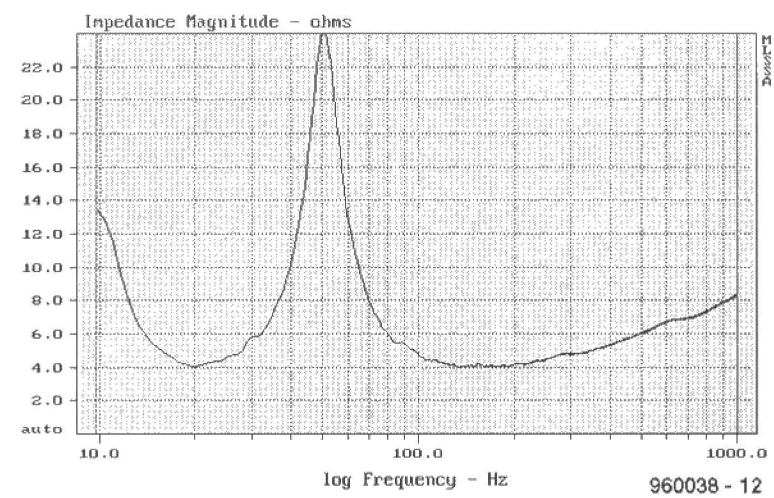
The impedance characteristic of the drive unit is shown in **Fig. 2**. The two voice coils are connected in parallel to obtain a reliable curve (which means that for each coil double the impedance value must be taken). The curve shows two peaks. The lower one at about 10 Hz results from the bass reflex alignment (which, by the way, is exactly in line with the 23 Hz resonator). The second peak, just above 50 Hz, is caused by the resonance frequency of the drive unit in the box.

Normally, filtering of a subwoofer starts at around 100 Hz or slightly lower to ensure good matching with the standard stereo loudspeakers. A passive filter, however, has the drawback that it functions properly only if it is terminated into a pure resistance. If the cut-off point were chosen at 100 Hz, the 52 Hz peak would create a problem: the resulting overall curve of a theoretically computed filter would not be usable. To solve this problem, the impedance curve of the drive unit has to be corrected. This is often effected by connecting parallel across its terminals (for each channel) an *RLC* network with the same resonant frequency. Unfortunately, at such low frequencies, the values of the necessary inductors and capacitors are such that they result in physically large (and expensive) components.

The solution in the present design consists simply of shunting the voice coil with a resistor. This does not totally eradicate the peaks, but

Fig. 2. The impedance curve when the two voice coils are in parallel. The high peak poses a problem for the passive filter.

2



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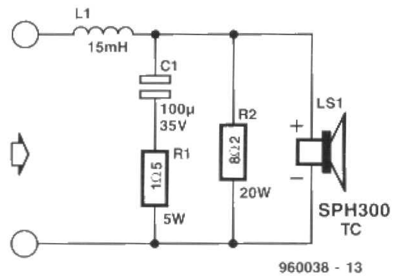

Fig. 3. The filter has been kept simple. Resistor R2 corrects the impedance curve. Inductor L1 and capacitor C1 provide a slope of 12 dB per octave and a high cut-off point at about 105 Hz.

flattens them sufficiently to enable a simulation program—Calsod—correcting the filter such that its frequency response is close to requirements.

To keep the number of components small, the filter is a second-order type consisting of conductor L_1 and capacitor C_1 (see **Fig. 3**). The resistor in series with the capacitor damps the *LC* circuit to some extent. The effect of the filter is shown in **Fig.** 4. Although the high cut-off point is about 105 Hz, the response will ensure a good match to most small loudspeakers.

BUILDING THE BOX

The prototype box is made from 28 mm thick medium-density chipboard (MDF), but, as in some cases it may not be possible to obtain this, 22 mm thick chipboard may be used (note that the dimensions in **Fig. 5** must then be adapted as appropriate). The box consists of six rectangular sheets and a stiffening crosspiece which are firmly fixed together with a suitable heavy-duty glue.

At one side are the apertures for the drive unit and acoustical resonator. The resonator consists of a 365 mm long piece of 80 mm dia. PVC pipe available from a builders merchant.

The four banana sockets for connecting the cables from the amplifier are fitted at the bottom of the one of the side panels.

The box is designed to rest on four 50 mm high legs with the drive unit fitted at the bottom facing the floor of the living room.

After the glue has dried thoroughly and the material has been sand-papered, the box can be given a final coat to individual taste.

The box is half filled (up to the cross piece) with suitable loudspeaker wadding, but take care that the opening of the pipe remains reasonably free of it.

The filter components are available from a specialist audio/hi-fi retailer or a good electronics shop. The inductor is a 15 mH type with a 56 mm ferrite core, preferably an HQ56 from IT. The capacitor is a bipolar type with smooth terminals.

The filter components may be glued to a small sheet of wood,chipboard, or prototyping board and then wired together. Note that some retailers stock general-purpose filter boards.

Fig. 4. The frequency response of the loudspeaker and filter combination. It ensures correct matching to most smaller stereo loudspeakers.

Screw the completed filter into the box and wire it up as shown. Take care not to interchange the plus and minus connections to the two channels. The cables to the drive unit must be terminated into cable clips to avoid the necessity of having to solder to the drive unit terminals.

Place the resonator in position, make the connections to the drive unit (make sure that the connections to the + terminals match, otherwise the drive unit does not work). Finally, place a strip of draught-excluding tape under the rim of the drive unit and screw the unit to the box.

Some constructors (or their wives) may find it aesthetically pleasing to place a sheet of glass, marble or similar material on top of the box to give it the look of a side table.

The passive subwoofer is then ready for use. It may be connected in parallel with the existing stereo speakers. It will work most satisfactorily when its efficiency of about 88 dB W^{-1} m^{-1} corresponds roughly to that of the existing loudspeakers and it is placed in close proximity to these. Note that if you want the active version, which will be described next month, you do not need the passive filter; the box remains the same.

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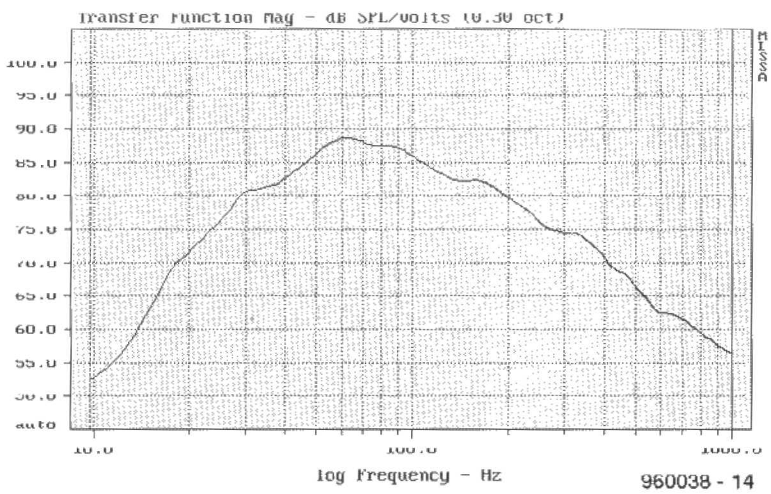
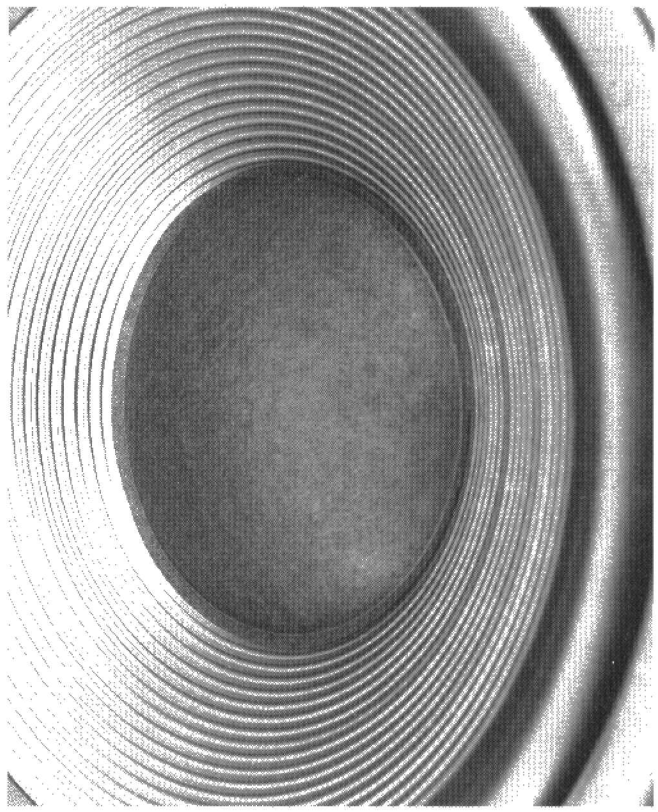


Drive unit revisited

During the design of the loudspeaker, a thorough search was made for a 300 mm drive unit at a reasonable price (to keep total costs down to not more than £ 80–90). Of course, such an economy-price unit cannot be expected to be perfect. And, indeed, in the testing of the SPH-300TC unit, it appeared that the parameters stated by the manufacturer did not agree with our own measurements. Fortunately, the deviations were beneficial to the box dimensions. Also, there was a kind of rustling noise at large cone movements. This was suspected in the first instance to be caused by a loose cone or air leak, but a second example exhibited exactly the same noise. A detailed investigation showed that the dust hood in the cone (the convex cap that closes the upper side of the cone) was the culprit. Its material is fairly soft, so that at large cone movements it begins to vibrate at its own (higher) frequency and thus causes the rustling noise. This deficiency is easily negated by spraying the dust hood a couple of times with a suitable plastic spray or applying a few layers of a suitable cone impregnator. This makes the cap more rigid so that it is not set into vibration at large cone movements.
The Parts Express unit appears to be rather more rugged than the Radio Shack and is rather cheaper.



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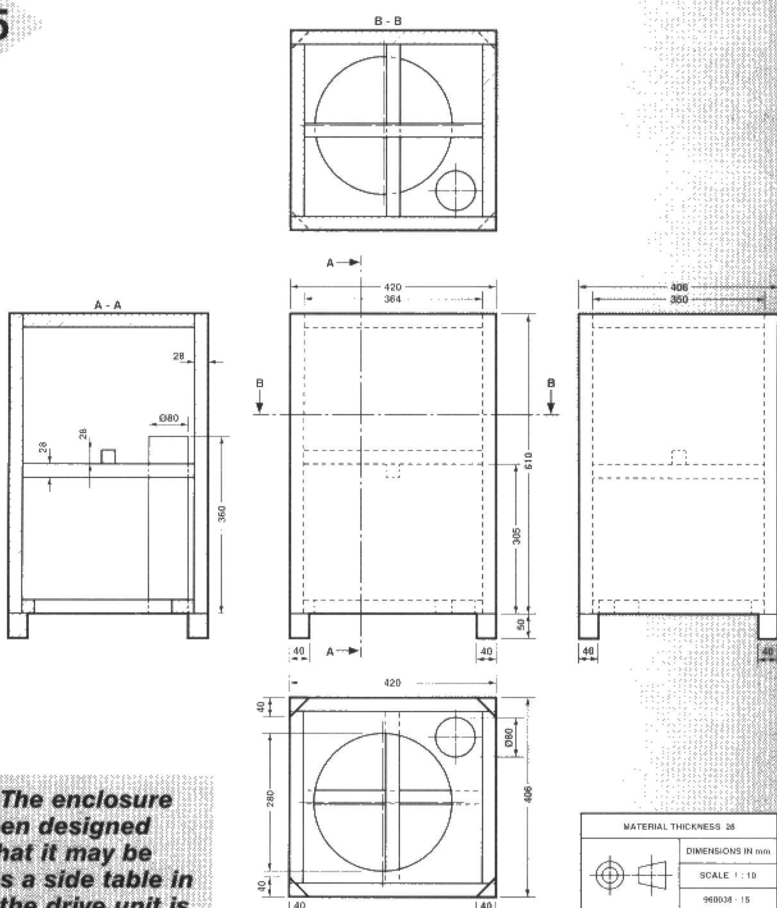


Fig. 5. The enclosure has been designed such that it may be used as a side table in which the drive unit is not (or hardly) visible.

Letters

Component availability

Dear Editor—I recently decided to build a decent hi-fi amplifier and chose a design by Mr Giesberts (September 1995). I have several problems which need to be resolved which, I feel, should not have arisen in a magazine for the amateur constructor who would have a limited number of sources for components.

1. **10000 μF, 50 V capacitors**. The PCB layout requires a 30 mm dia. component (a 35 mm dia. type will foul other components on the PCB, but is more commonly available. After much searching, I found three manufacturers: Elna, Dubilier and Rubycon. The distributors for Elna seem to stock only the 35 mm dia. size (although Elna do both 30 mm and 35 mm); the Dubilier item requires a £250 minimum order. The Rubycon items are stocked by C&CD of Lane End, Bucks (01494 882848), part nos 50USP10000MC40 (40 mm long and 5.02 A ripple) and 50MXR10000MC50 (50 mm long and 4.05 A ripple). Note that the professional Maplin catalogue advertises a 30 mm item, but this is a typo: it should be 35 mm.

2. **IGBT output devices.** These transistors are single source from Toshiba and are not commonly stocked by their franchised distributors. A non-franchised distributor, Steatite (0121 643 6333, contact Jenny Skinner) is the *only* stockist in the UK according to Toshiba.

3. **E96 resistors**. Are some of the designs by Mr Giesberts so critical that *only* resistors from the E96 range can be used? May I refer to Lindsey-Hood, Douglas Self, Bengt Olsen, *et al*, whose state-of-the-art hi-fi amplifier design (*EWW*) seems only to use the E24 range of resistors.

4. **Fischer SK84 heat sink.** The parts list states that the thermal characteristic of the heat sink required is 0.6 K W^{-1}. The photograph in the Sept. 95 article shows a heat sink where the height is half the width of about 75 mm. In the Fischer catalogue No. 12, page A21, the graph clearly shows that for a stock length of 75 mm the thermal characteristic is about 1.15 K W^{-1}. Which is correct, 0.6 K W^{-1} or 1.15 K W^{-1}?

5. **Screw terminals**. Where, oh where, does one get the PCB mounted screw terminals on the main amplifier PCB for the supply and speaker leads in the UK?

6. **Single or twin power supply**? It is surprising that consideration has not been given to the power supply construction and ratings with a suitably rated PCB (twice the current and twice the number of reservoir capacitors?) for a stereo unit.

7. **Terminal pin hole size**. What size are the holes for the terminal pins which are used for connecting wires to and from the PCB? The holes used are too large for commonly available (Vero) pins which are normally 1.04 mm. Where can I source the correct size push-fit pin?

8. **Tone controls.** I recently enquired abut tone control circuits for use with this amplifier and received the curt reply that tone controls are 'out' as though they re some fashion accessory and are no used in 'real' hi-fi amplifiers. Firstly, I (an no doubt many other readers) still have older recordings which need judicious adjustment of the bass d treble response to compensate for the poor quality recording. Secondly, I do not have a specially laid-out 'listening room', but a small living room in which anything larger than my KEF101 loudspeaker would be out of place. Thirdly, I am in my late fifties and in common with *everyone* (younger hi-fi purists, please note), my hearing frequency range has reduced as I have got older, so I do sometimes need to 'tweak' the treble a little bit. Fourthly, the statement that tone controls are not part of the hi-fi scene is based on the *assumption* that the recording engineer has carried out his/her task to perfection and that the equipment used in the studio is beyond reproach. Last, but not least, I object strongly to some hi-fi follower of fashion telling me how I should listen to my(mostly classical and some R&B)music! By the way, it would be a fallacy to assume that reduced hearing frequency range equates to reduced sensitivity to distortion.

I feel that information on the sourcing of suitable components in the UK is sadly lacking. The assumption by the continentals that the hobbyist in the UK has access to instant knowledge of where to get any component dreamt up by the designer seems not far short of arrogance.

I feel that *Elektor Electronics* should set the standard here by issuing guidelines to contributors to use components that are commonly available world-wide. The magazine could suggest that designers only choose components from a list of *Elektor Electronics* defined distributors that are available for the hobbyist both on the Continent, in the UK and in the USA, and that specialist components are source identified by the contributor.

[Alan Beaman, Bracknell]

1 & 2. Many electronics retailers, including our own advertisers, are provided with a preview, incl. parts list, of the magazine content about three weeks before the publishing data of the magazine to enable them to obtain stock of parts used. The preview states the manufacturer or other source of any less common device.

Mr Giesberts comments as follows:

3. "When matched transistors are used, 1% tolerance components are necessary, otherwise the use of matched components would make no sense. The E24 range is, theoretically, a 2%-tolerance series. In practice, however, E96 will be supplied even if the same value is found in the E12 series. It is true that 1% resistors may be found in the E24 series. Unfortunately, kits often contain 5% types, obviously since these are cheaper. It is always possible to use E24 types even if E96 types are specified as long as one is prepared to accept a slight degradation of quality".

4. "In Fischer catalogues up to 1993, a wrong graph was printed with the data for the SK85 heat sink. From the 1994 catalogues onwards, it is stated that an SK85 heat sink is 75 mm high and has a thermal resistance of about 1.2 K W^{-1}. The R_{th} value indicated in our parts list should have corresponded to that value. In practice, a doubled thermal resistance dos no harm, because the design is based on a worst-case situation. Nevertheless, it is recommended to use a heat sink that meets the specified thermal resistance rating".

5. "A possible solution, better than the original one, is to terminate the cable into a cable eye and secure it with a screw directly at the copper side".

6. "To prevent earthing loops (which cause hum), a mono supply is recommended. For anyone who is after quality, the possible cross-effects that a stereo supply may have on the two channels, the wiring (a 'star' configuration is not ideal) and particularly the radiation of the supply cables are good reasons to make use of a mono supply. In fact, it is better to build two mono amplifiers".

7. "It is better to make use of soldering eyelets, which normally have a wedge".

Finally, we apologize for the curt reply you got to your query on tone controls. We fully share your feelings that in many cases tone controls are not only required, but are essential. Nevertheless, some amplifiers we publish have no tone control and these are aimed especially at readers who do not feel a tone control is necessary.

[Editor]

Electronic magazines

Dear Editor—By all means make your publication available 'electronically' for the anorak wearing minority ('Letters' – F R Fattori, Dec 1995).

But please continue to present it properly for those of us who still live on the surface of the planet.

It is one thing to read a letter on screen. Reading a technical article, where it is necessary to frequently refer to different pages as one proceeds is quite another. The only feasible way to read an electronic version of a magazine such as yours would be to first print out the whole thing! In which case it might as well be on the more *flexible* medium in the first place.

I suspect that the demise of glossy magazines is as far off as the long predicted paperless office – which is still further off than it was when paper was the only possibility. Nevertheless, I write (with word processor, of course – but on paper) just in case you are tempted.
A. Jaques, Manchester

We entirely agree with you that the 'electronic paper' and 'electronic magazine' are a long way off and even then they will remain adjuncts to the 'real thing'. A pointer to this is that paper usage, in spite of steeply rising prices has more than quadrupled over the past twenty years.

[Editor]

Mediocrity ...

Dear Editor—Your new front cover will not compensate for your mediocrity in technology.
Anonymus, Bradford

And excellence ...

Dear Editor—Thank you for a very informative magazine. If it were not for you, I would not be a electromedical technician. I have gained a lot of knowledge from your excellent magazine.
Anton Carstens, Capetown

PIC Programmer

Dear Editor—Is there any intention in future to provide a software/hardware upgrade for the PIC Programmer that I have constructed from your March 1994 issue.

The problem that I have is that all my work so far has been using 16C54s with which I have no problems in programming (except that I initially received a 17C42 from one of your dodgy batches supplied with the PCB I ordered).

I still have not found an advertisement for LTP, the company referred to in the article who supply the DB3 enclosure.
J. Palmer, Burton-on-Trent

There are no plans (yet) for upgrades of the PIC Programmer, but the one you built may be modified to enable PIC16C71 devices to be programmed by connecting a 100 kΩ resistor between pin 18 of U_1 and ground.

The address of LTP is
La Tolerie Plastique, Z.I. Route d'Etretat, F-76930, Octeville-sur-Mer, France.
Telephone +33 35 449 292
Fax +33 35 449 599.

[Editor]

SmartCards

Dear Editor—I am a student taking a B.Eng (Hons) Combined Technologies (Microelectronics) course. I am engaged in a major project involving the (possible) use of SmartCards. I should be grateful if you would supply me with information relating the card reader in Fig. 7, p. 17, of your April 95 issue.
S. Davey, Braintree

The SmartCard reader referred to is produced by ITT Cannon. It should be available from the distributor, Avnet Time, Jubilee House, Jubilee Road, Letchworth, Herts SG6 1QH.
Telephone 01462 484444.
Fax 01462 488646.

[Editor]

Construction guidelines

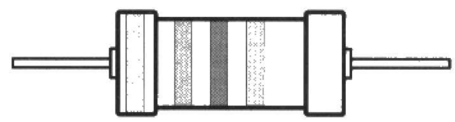
Elektor Electronics (Publishing) does not provide **parts and components other than PCBs**, front panel foils and software on diskette or IC (not necessarily for all projects). Components are usually available from a number of retailers—see the adverts in the magazine.

Large and small values of components are indicated by means of one of the following prefixes:

E (exa) = 10^{18}	a (atto) = 10^{-18}
P (peta) = 10^{15}	f (femto) = 10^{-15}
T (tera) = 10^{12}	p (pico) = 10^{-12}
G (giga) = 10^{9}	n (nano) = 10^{-9}
M (mega) = 10^{6}	μ (micro) = 10^{-6}
k (kilo) = 10^{3}	m (milli) = 10^{-3}
h)hecto) = 10^{2}	c (centi) = 10^{-2}
da (deca) = 10^{1}	d (deci) = 10^{-1}

In some circuit diagrams, to avoid confusion, but contrary to IEC and BS recommendations, the value of components is given by substituting the relevant prefix for the decimal point. For example,
3k9 = 3.9 kΩ; 4μ7 = 4.7 μF.

Unless otherwise indicated, the tolerance of resistors is ±5% and their rating is ⅓–½ watt. The working voltage of capacitors is ≥ 50 V.



The value of a resistor is indicated by a **colour code** as follows.

colour	1st digit	2nd digit	mult. factor	tolerance
black	--	0	--	--
brown	1	1	$\times 10^{1}$	±1%
red	2	2	$\times 10^{2}$	±2%
orange	3	3	$\times 10^{3}$	--
yellow	4	4	$\times 10^{4}$	--
green	5	5	$\times 10^{5}$	±0.5%
blue	6	6	$\times 10^{6}$	--
violet	7	7	--	--
grey	8	8	--	--
white	9	9	--	--
gold	--	--	$\times 10^{-1}$	±5%
silver	--	--	$\times 10^{-2}$	±10%
none	--	--	--	±20%

Examples:
brown-red-brown-gold = 120 Ω, ±5%
yellow-violet-orange-brown = 47 kΩ, ±1%.

In **populating a PCB**, always start with the smallest passive components, that is, wire bridges, resistors and small capacitors; and then the IC sockets, relays, electrolytic and other large capacitors, and connectors. Vulnerable semiconductors and ICs should be done last.

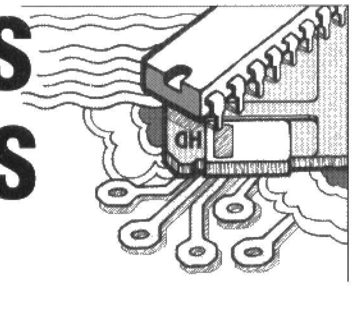
Soldering. Use a 15–30 W soldering iron with a fine tip and tin with a resin core (60/40). Insert the terminals of components into the correct holes in the board, bend them slightly, cut them short, and solder: wait 1–2 seconds for the tin to flow smoothly and remove the iron. Do not overheat, particularly when soldering ICs and semiconductors. Unsoldering is best done with a suction iron or special unsoldering braid.

Faultfinding. If the circuit does not work, carefully compare the populated board with the published component layout and parts list. Are all components in the correct position? Has correct polarity been observed? Have the power lines been reversed? Are all solder joints sound? Have any wire bridges been forgotten?

If voltage levels have been given on the circuit diagram, do those measured on the board match them—note that deviations of up to ±10% from the specified values are acceptable.

Possible corrections to published projects are published from time to time in this magazine. Also, the readers letters column often contains useful comments/additions to the published projects.

READERS SERVICES



MARCH 1996

GENERAL

Ready-made printed-circuit boards (PCBs), self-adhesive front panel foils, ROMs, EPROMs, PALs, GALs, microcontrollers and diskettes for projects which have appeared in *Elektor Electronics* may be ordered using the order form printed opposite. The form may also be used to order books (private customers only).

- Items marked with a dot (•) following the product number are in limited supply only, and their availability can not be guaranteed by the time your order is received.
- Items not listed here are not available.
- The artwork for making PCBs which are not available ready-made through the Readers Services may be found in the relevant article (from March 1990 onwards).
- EPROMs, GALs, PALs, (E)PLDs, PICs and other microcontrollers are supplied ready-programmed.

Prices and item descriptions subject to change. The publishers reserve the right to change prices without prior notification. Prices and item descriptions shown here supersede those in previous issues. E. & O.E.

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Except in the USA and Canada, all orders, except for subscriptions and past issues (for which see below), must be sent BY POST to our Dorchester office using the Order Form opposite. Please note that we can not deal with PERSONAL CALLERS, as no stock is carried at the editorial and administrative office.

Readers in the USA and Canada should send orders, except for subscriptions (for which see below), to Old Colony Sound Lab, Peterborough NH, whose full address is given on the order form opposite. Please include shipping cost according to total order value. For surface delivery in the USA, if order is less than $50, include $3; $50+, $4. For Canada surface, if less than US$50, include US$5; US$50+, US$7.50. For air or other deliveries, please inquire. Please allow 4-6 weeks for delivery.

All other customers must add postage and packing charges for orders up to £25.00 as follows UK and Eire £1.95; surface mail outside UK £2.45. Europe (airmail) £2.95; outside Europe (airmail) £3.70. For orders over £25.00, but not exceeding £100.00, these p&p charges should be doubled. For orders over £100.00 in value, p&p charges will be advised.

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Unless you have an approved credit account with us, all orders must be accompanied by the full payment, including postage and packing charges as stated above.

Payment may be made by cheque **drawn on a London clearing bank** (but see para. 4 below), postal order, VISA, Access, MasterCard or EuroCard (when paying by credit card, the order must go the cardholder's address). Do not send cash through the mail. Cheques and postal orders should be crossed and made payable to 'Elektor Electronics (Publishing)'.

Payment may also be made by direct transfer from a private or business Giro account to our **Giro account No. 34 152 3801** by completing and sending to the National Giro Centre, in a National Giro postage paid envelope, a National Giro transfer/deposit form. Do not send Giro transfers direct to us, as this will delay your order.

If you live outside the UK, payment may also be made by Bankers' sterling draft **drawn on a London clearing bank, Eurocheque** made out in pounds sterling (with holder's guarantee card number written on the back), or US or Canadian dollar cheque, but such cheques, accepted at the exchange rate prevailing at the time your order is received, **must be increased by the equivalent of £15.00** to cover our bankers' negotiating fee

If you pay by Bankers' sterling draft, make clear to the issuing bank that your full name and address MUST be communicated to the London clearing bank.

Our bankers are **National Westminster Bank, 49 South Street, DORCHESTER, Dorset DT1 1DW, England**. Our account number is **6966 3340**.

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Subscriptions and past issues, if available, should be ordered from **Worldwide Subscription Service Ltd, Unit 4, Gibbs Reed Farm, Pashley Road, TICEHURST TN5 7HE, England.** For subscriptions, use the subscriptions order form elsewhere in this magazine.

Prices of past issues (except July/August and December), including postage for single copies, are £2.70 (UK and Eire); £3.00 (surface mail outside UK); £3.20 (air mail Europe); £3.95 (airmail outside Europe). Prices of past July/August and December issues, including postage for single copies, are £3.75 (UK); £4.00 (surface mail outside UK); £4.25 (airmail Europe) and £5.00 (airmail outside Europe)

PAST ARTICLES

For information on past articles, please contact our Editorial and Administrative Office in Dorchester (telephone 01305 250995; fax 01305 250996).

COMPONENTS

Components for projects appearing in *Elektor Electronics* are usually available from appropriate advertisers in this magazine. If difficulties in the supply of components are envisaged, a source will normally be advised in the article. It should be noted that the source(s) given is (are) not exclusive — other suppliers may also be able to help.

TERMS OF BUSINESS

Delivery Although every effort will be made to dispatch your order within 2-3 weeks from receipt of your instructions, we can not guarantee this time scale for all orders.

Returns Faulty goods or goods sent in error may be returned for replacement or correction, but not before obtaining our consent. All goods returned should be packed securely in a padded bag or box, enclosing a covering letter stating the dispatch note number. If the goods are returned because of a mistake on our part, we will refund the return postage. Goods returned for refund must be in resaleable condition and will be subject to a 10% handling charge with a minimum charge of £2.50.

Damaged goods Claims for damaged goods must be received at our Dorchester office within 10 days (UK); 14 days (Europe) or 21 days (all other countries) from the date on our 'Recorded delivery' slip.

Cancelled orders All cancelled orders will be subject to a 10% handling charge with a minimum charge of £2.50.

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July 1995

Article title	Order no.	Price (£)	(US$)
MARCH 1996			
Houseplant Buzzer (4 on 1 board)	950118-1	10.00	20.00
PIC-Controlled RDS Decoder:			
- PCB + PIC (966505-1)	960050-C	27.50	55.00
- PIC 16C84	966505-1	22.75	45.50
Satellite Finder		Not Available	
General-purpose Audio filter		Not Available	
FEBRUARY 1996			
SIMM tester:			
- PCB + EPROM (966503-1)	960039-C	28.25	56.50
- EPROM	966503-1	10.25	20.50
I²C Interface for Centronics port:			
- PCB + disk (946202-1)	950063-C	20.25	40.50
- control software on disk	946202-1	12.25	24.50
Passive VU meter	950124-1	8.00	16.00
FM Receiver in SMT	936049	5.00	10.00
Icy Roads Warning	960029-1	6.00	12.00
Design Competition projects:			
- µC Switching Clock RTC56*	DISK SET, Order code 966002-1. Price £11.50 or US$23.		
- PC Controlled Battery Tester*			
- PWM Signal Generator*			
- Intelligent Motor Control for R/C Models*			
* Disclaimer: this software has not been tested by Elektor Electronics (Publishing)			
JANUARY 1996			
SECAM-to-PAL Converter	950078-2	29.00	58.00
Copybit Inverter			
- PCB + MACH/GAL	950104-C	44.00	88.00
- MACH/GAL		35.25	70.50
Passive Component Tester			
- PCB	960032-1	13.75	27.50
- Front panel foil		Not available	
Design Competition projects			
- 8-bit Logic Analyser*	DISK SET, Order code 966002-1. Price £11.50 or US$23.		
- Remote Monitor for CH Systems*			
- Simple Stepper Motor Controller*			
- Telly-Guard*			
- SmartCard Reader*			
* Disclaimer: this software has not been tested by Elektor Electronics (Publishing).			
DECEMBER 1995			
3.3-15V Power Supply	950106-1	9.25	18.50
Practice Amplifier for Guitars	950016-1	17.25	34.50
Smart Transistor Tester:			
- PCB + PIC (956502-1)	950114-C	44.25	88.50
- PIC 16C71	956502-1	35.50	71.00
Micro PLC System:			
- PCB + 87C750/51 + disk	950093-C	44.50	89.00
- 87C750/51	956514-1	24.50	49.00
- control software on disk	956016-1	10.00	20.00
Active potentiometer	954099-1	9.50	19.00
Descaler	954080-1	5.75	11.50
Active probe	954093-1	8.00	16.00
Two-way PC-Fax Interface	954033	11.75	23.50
50-MHz 16/32-bit Logic Analyser			
- system disk for PCs*	956018-1	5.00	10.00
IC Programming Service			
Send blank ispLSI1016 or pLSI1016 ICs (Lattice). Programming charges only, no ready-burned ICs!			
- IC5*	956516-1	6.00	12.00
- IC6* or IC15*	956516-2	6.00	12.00
* Disclaimer: this software has not been tested by Elektor Electronics (Publishing).			
NOVEMBER 1995			
PIP Processor:			
- PCB + 87C51 (956505-1)	950078-C	54.75	109.50
- 87C51	956505-1	30.75	61.50
FM noise squelch	950089-1	10.75	21.50
PA 300 power amplifier	950092-1	19.75	39.50
Jogging LED	950112-1	7.00	14.00
Oscilloscope prescaler	950115-1	27.75	55.50
OCTOBER 1995			
MatchBox BASIC computer:			
- PCB, 87C51, disk and Quick Reference Card	950011-C	59.25	118.50
- 87C51	956508-1	43.50	87.00
- Course diskette (DOS)	956009-1	11.50	23.00
- Quick Reference Card	950011-P	3.25	6.50
Special Autumn Supplement:			
- Experimentation board for PICs, incl. free disk for *PLC Emulation Using PIC Micro-controllers*	944105-1	17.75	35.50
SEPTEMBER 1995			
Hi-Fi headphone amplifier	950064-1	5.00	10.00
Dongle safe			
- PCB	950069-1	12.75	25.50
- GAL IC2 (20V8)	956511-1	10.00	20.00
- GAL IC6 (22V10)	956512-1	11.75	23.50
HexFET power amp upgrade:			
- amplifier PCB	930102	12.75	25.50
- power-on delay PCB	924055	6.45	12.90
Copybit eliminator update:			
- PCB + MACH (956504-1)	950084-C	40.50	81.00
- MACH IC	956504-1	36.50	73.00
RF tone-dip oscillator	950095-1	5.25	10.50
JULY/AUGUST 1995			
Active mini subwoofer	936047	12.25	24.50
Mini robot car	936069	8.00	16.00
Simple RF function generator	950023-1	7.50	15.00
Alkali/Manganese battery charger	950056-1	6.75	13.50
Fast charger for NiCd batteries:			
- PCB + ST62T20 (956509-1)	950076-C	22.75	45.50
- ST62T20	956509-1	14.75	29.50
Simple I/O card	954074-1	11.50	23.00
6-V motive battery charger	940083-1	7.25	14.50
JUNE 1995			
Function generator:			
- PCB	950068-1	29.50	59.00
- Front panel foil	950068-F	17.75	35.50
Electronic sandglass:			
- PCB + 87C751 (946647-1)	950052-C	26.25	52.50
- 87C751	946647-1	17.75	35.50
Auto light control	950050-1	4.75	9.50
VGA distribution amplifier	950017-1	10.00	20.00
MAY 1995			
MIDI analyser:			
- PCB + EPROM (956507-1)	940020-C	34.25	68.50
- EPROM	956507-1	16.75	33.50
Programmer for 87/89C51 series Flash controllers:			
- PCB + EPROM (956644-1)	950003-C	26.50	53.00
- EPROM	946644-1	14.50	29.00
Programmable sine wave generator:			
- PCB + disk (956005-1)	950004-C	19.50	39.00
- control software on disk	956005-1	12.25	24.50
NiCd battery-quality tester:			
- PCB + ST62T15 (956506-1)	950051-C	25.25	50.50
- ST62T15	956506-1	18.25	36.50
APRIL 1995			
Electronic barometer	936033	8.50	17.00
Bat detector	936046	10.25	20.50
Sun blind control	950035-1	9.25	18.50
Function generator:			
- PCB + front panel foil	950044-C	21.75	43.50
- PCB	950044-1	11.00	22.00
- Front panel foil	950044-F	12.50	25.00
Stepper motor control:			
- PCB + 8751 + disk	950038-C	50.75	101.50
- 8751	956503-1	35.25	70.50
- test program on PC disk	956004-2	3.75	7.50
MARCH 1995			
Telephone-controlled mains switch:			
- PCB + PIC (946642-1)	950010-C	22.00	44.00
- PIC 16C54	946642-1	17.50	35.00
DSP function generator:			
- PCB + disk (956001-1) + EPROM (956501-1)	950014-C	49.00	98.00
- EPROM 27C512	956501-1	13.25	26.50
- software on IBM PC disk	956001-1	18.50	37.00
- Windows program manual	950014-P	7.50	15.00
TDA1560Q car audio amplifier	950024-1	9.50	19.00
FEBRUARY 1995			
MIDI multiplexor	930101	15.00	30.00
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Infrared dimmer	940109-1	9.75	19.50
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Surround sound processor	950012-1	18.75	37.50
Induction motor governor	940095-1	7.50	15.00
JANUARY 1995			
Mini Audio DAC	940099-1	14.75	29.50
1-to-3-phase converter:			
- PCB + GAL + EPROM	940077-C	52.75	105.50
- GAL	946640-1	12.25	24.40
- EPROM	946640-2	15.75	31.50
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- PCB + GALs (946639-1/2)	950008-C	29.25	58.50
- GAL-1	946639-1	11.00	22.00
- GAL-2	946639-2	13.00	26.00
Self-loading EEPROM type X88C64 SLIC	940116-1	8.25	16.50
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- software on IBM PC disk	946203-1	11.50	23.00
Quasi-analogue clockwork	930024	37.25	74.50
DECEMBER 1994			
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ispStarter kit from Lattice			
- PCB + disk (946204-1)	940093-C	21.50	43.00
- Examples on PC disk	946204-1	9.75	19.50
NOVEMBER 1994			
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OCTOBER 1994			
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- preamplifier PCB	936062-2	28 25	56.50
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- PCB + PIC (946643-1)	940065-C	26.25	52.50
- PIC 16C54	946643-1	20.25	40.50
SEPTEMBER 1994			
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- sensor board (option)	940045-1	6.00	12.00
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JULY/AUGUST 1994			
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- EPROM 27C64	946635-1	13.75	27.50
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- software on IBM PC disk	1951	10.75	21.50
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- software on IBM PC disk	1901	10 75	21.50
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- files and misc. utilities on			

Article title	Order no.	Price (£)	(US$)
IBM PC disk	946196-1	9.75	19.50
JUNE 1994			
80C535 SBC extension:			
- software on IBM PC disk	1941	9.75	19.50
- I²C display software on IBM PC disk	946197-1	9.75	19.50
I²C bus booster	940057-1	7 25	14.50
RS485 interface	940035-1	6.25	12.50
Fuel consumption monitor	940045-1	6.00	12.00
Intelligent EPROM eraser	940058-1	9.00	18.00
MAY 1994			
Mains signalling system - 2.			
- transmitter PCB, disk (1911) and EPROM (6371)	940021-2C	33.25	66.50
- EPROM 27C64	6371	13.25	26.50
- software on IBM PC disk	1911	9,75	19.50
APRIL 1994			
Mains signalling system - 1:			
- receiver board	940021-1	10.25	20 50
68HC11 processor board	930123	7.75	15.50
Headphones amplifier	940016	18.75	37 50
MARCH 1994			
80C535 assembler course:			
- EMON52 ROM + disk (1811)	6221	17.05	34.10
- disk (IBM PC format)	1811	8.80	17.60
PIC programmer			
- PCB + software set (7161)	940048-C ●	66 00	132.00
- PIC17C42 + PC disk	7161	52.75	105.50
100W AF amplifier			
- adaptor board	930039	8.25	16.50
- amplifier board	920135-1	19.40	38.80
- protection board	920135-2	7.95	15.90
FEBRUARY 1994			
80C535 single-board computer	924046	14.10	28 20
Copybit eliminator:			
- PCB + MACH + GAL	930098-C ●	46.25	92 50
- MACH + GAL	6321	42.25	84.50
Mini preamplifier	930106	29.25	58 50
Bidirectional RS232-to-Centronics converter	930134	14.00	28.00
JANUARY 1994			
SIM — an 8051 simulator:			
- software on IBM PC disk	1931	34.25	68.50
Digital dial	920161	12.75	25.50
RDS decoder:			

Article title	Order no.	Price (£)	(US$)
- PCB + EPROM (6331)	930121-C	23.75	51.50
- EPROM 27C64	6331	14.50	29.00
I²C tester:			
- PCB + GAL (6341)	930128-C	36.25	72.50
- GAL type 6001	6341	30.75	61 50
Telephone-controlled switch:			
- EPROM 2764	6271	14.50	29 00
DECEMBER 1993			
535 card with EPROM emulator:			
- GAL and PAL	6311	26.00	52.00
RMS AF voltmeter:			
- PCB	930108	12.25	24.50
- front panel foil	930108-F	17.25	34.50
I²C power switch	930091	6.25	12.50
Medium power HEXFET amplifier	930102	12.75	25.50
Microcontroller-driven UART:			
- PCB	930073	4.75	9.50
- ST62T10	7151	17.25	34.50
SCART switching box	930122	14 25	28.50
NOVEMBER 1993			
Precision clock for PCs:			
- PCB + disk (1871)	930058-C	12 25	24.50
- software on IBM Pc disk	1871	8.50	17.00
VHF/UHF TV tuner			
- PCBs -1 and -2, and µC 87C51 (7141)	930064-C	57.25	114.50
- µC 87C51	7141	25.75	51 50
Output amplifier with AF bandpass filter	930071	6.75	13 50
Digital hygrometer:			
- PCB + EPROM (6301)	930104-C	28.00	56.00
- EPROM 2764	6301	14.50	29.00
Power MOSFET tester	930107	32.50	65.00
OCTOBER 1993			
Stereo mixer	UPBS-1	1.95	3.90
MIDI channel monitor	930059	14.00	28.00
Ah meter with digital display	930068	14 00	28.00
Autoranging frequency readout	930034	12.50	25.00
ROM-gate switchover for Atari ST	930005	30.25	60.50
Microntroller-driven NiCd battery charger			
- board and ST62E15	920162-C	25.50	51.00
- ST62E15	7071	10.00	20.00
Fuzzy logic multimeter - 2:			
- PCB + Fuzzy Control One	920049-C	23.75	47.50
- Fuzzy Control One disk	1721	7.75	15.50

continued overleaf

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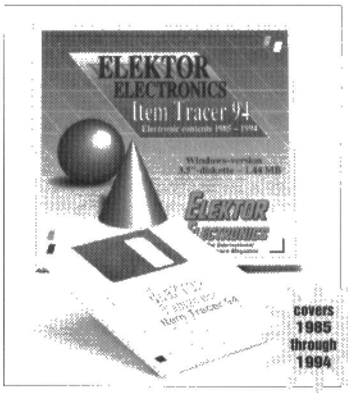
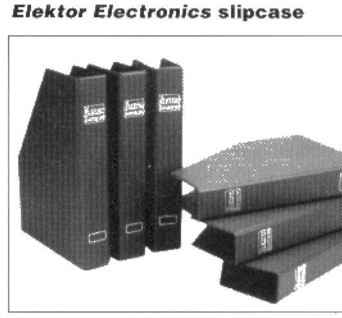


Min. requirements: Windows 3.1, 386 CPU, 4 MByte RAM, 2 Mbyte HD space. Windows 95 compatible.
Price: £15.00, £12.00 for subscribers (please quote your subscription number when ordering).
Order code: 956014-1

***Elektor Electronics* slipcase**



Price: £2.95 + P&P (£1.50 UK: £2.00 outside UK)

Article title	Order no.	Price (£)	(US$)
SEPTEMBER 1993			
Fuzzy logic multimeter - 1	920049-2	20.00	40.00
Linear temperature gauge	920150	7.05	14.10
PC-aided transistor tester			
- PCB	920144	9.75	19.50
- software on IBM PC disk	1781	7.50	15.00
Harmonic enhancer	930025	13.50	27.00
I²C alphanumerical display:			
- PCB + disk (1851)	930044-C	14.25	28.50
- Software on IBM PC disk	1851	8.50	17.00
Mini micro clock			
- PCB	930055	7.50	15.00
- clock: ST62T15	7111	11.50	23.00
- darkroom timer: ST62T15	7121	11.50	23.00
- cooking timer: ST62T15	7131	11.50	23.00
950-1750 MHz converter	UPBS-1	1.95	3.90
JULY/AUGUST 1993			
Active 3-way loudspeaker system	930016	21.50	43.00
Maxi micro clock			
- PCB	930020	15.50	31.00
- clock ST62T10	7081	11.50	23.00
- darkroom timer ST62T10	7091	11.50	23.00
- cooking timer ST62T10	7101	11.50	23.00
SMD soldering station	930065	9.50	19.00
VHF-low converter	926087	15.50	31.00
I²C bus fuse (5 on 1 PCB)	934016	8.00	16.00
Voice operated recording	934039	6.00	12.00
General transformer PCB	934004	6.50	13.00
Plant humidity monitor	934031	4.50	9.00
Plant humidity monitor (supply)	934032	4.00	8.00
Four-fold DAC card for PCs:			
- GAL	6251	10.75	21.50
Multi-purpose display decoder:			
- EPROM 27128	6261	11.50	23.00
JUNE 1993			
Spectrum VU meter	920151	13.00	26.00
GAL programmer upgrade:			
- PCB	930060	4.50	9.00
- software on IBM PC disks	1701	11.15	22.30
- idem, w/o Opal Jr. disks	1881	10.75	21.50
- software on Amiga disk	1841	11.00	22.00
Digital frequency readout for VHF/UHF receiver	926001-2	11.50	23.00
Inexpensive phase meter:			
- main board	930046	9.00	18.00
- meter board	920018	4.70	9.40
- front panel foil	930046-F	17.25	34.50
X2404-to-8751 interfacing:			
- software on IBM PC disk	1891	8.50	17.00
MAY 1993			
FM stereo signal generator	920155	23.00	46.00
VHF/UHF receiver	926001	19.00	38.00
Philips preamplifier:			
- PCB	930003	7.50	15.00
- software on IBM PC disk	1861	8.50	17.00
Workbench PSU			
- main PCB	930033	21.50	43.00
- display PCB	920075-1	4.70	9.40
- front panel foil	930033-F	17.00	34.00
APRIL 1993			
Audio power meter	930018 •	10.25	20.50
Video digitizer for PCs:			
- PCB + disk (1831)	930007-C •	37.00	74.00
- Software on IBM PC disk	1831	14.50	29.00
Infrared receiver for 80C32 single-board computer:			
- PCB and disk (1791)	920149-C •	14.50	29.00
- software on IBM PC disk, also for DTMF decoder	1791	7.50	15.00
4MB printer buffer card:			
- PCB	920009 •	27.50	55.00
- EPROM 27C64	6041	15.30	30.60
- front panel foil	920009-F •	8.25	16.50
MARCH 1993			
Linear sound pressure meter	930006 •	7.00	14.00
Electrically isolated RS232 interface	920138 •	10.25	20.50
TV test pattern generator for 8032 SBC:			
- EPROM 27256	6151	15.30	30.60
FEBRUARY 1993			
Digital audio/visual system (4):			
- software package, EPROM, GALs and IBM PC disk	6181	30.50	61.00
U2400B NiCd battery charger:			
- PCB	920098 •	8.75	17.50
- front panel foil	920098-F •	8.75	17.50
Digital-audio enhancer	920169 •	14.25	28.50
I²C opto/relay card			
- PCB	930004 •	11.00	22.00
- software on IBM PC disk	1821	7.65	15.30
Watt-hour meter:			
- PCBs -1 and -2, and EPROM (6241)	920148-C •	37.25	74.50
- EPROM 27256	6241	10.00	20.00
JANUARY 1993			
PAL test pattern generator:			
- PCB + GAL (6211)	920129-C •	15.30	30.60
- GAL 20V8	6211	9.40	18.80
Multi-core cable tester			
- matrix board	926079 •	17.05	34.10
- slave unit	926084 •	6.20	12.40
- master unit	926085 •	8.25	16.50
DECEMBER 1992			
Digital audio/visual system:			
- PCB + EPROM (6171)	920022-C •	34.10	68.20
- EPROM 27C256	6171	10.30	20.60
- panel foil dissolve unit	920022-F1 •	10.00	20.00
- panel foil remote control	920022-F2 •	19.40	38.80
- panel foil main unit	920022-F3 •	28.80	57.60
1.2 GHz multifunction frequency meter:			
- PCB + EPROM (6141)	920095-C •	29.40	58.80
- EPROM 27C256	6141	11.45	22.90
- front panel foil	920095-F •	13.80	27.60
Output amplifier for ribbon loudspeakers	920135-1 •	19.40	38.80
	920135-2 •	7.95	15.90
Peak-delta NiCd charger	920147 •	4.10	8.20
IDC-to-boxheader adaptor	924049 •	6.45	12.90
Mini keyboard for Z80	924047 •	12.35	24.70
Mains power-on delay	924055 •	6.45	12.90
Speech/sound memory:			
- software on IBM PC disk	1771	7.65	15.30
NOVEMBER 1992			
Printer sharing unit	920011 •	14.70	29.40
Difference thermometer	920078 •	5.30	10.60
Low-power TTL-to-RS232 interface	920127 •	3.55	7.10
OCTOBER 1992			
Audio DAC - 3:			
- PCB	920063-3 •	26.45	52.90
- front panel foil	920063-F •	10.00	20.00
Mains sequencer	920013 •	17.35	34.70
Wideband active antenna	924101 •	3.25	6.50
RDS demodulator	880209 •	5.30	10.60
Pascal routines for Multi-function Measurement Card for PCs: software on disk	1751	9.70	19.40
SEPTEMBER 1992			
EPROM emulator - II:			
- PCB	910082 •	10.00	20.00
- software on IBM PC disk	129	6.75	13.50
JULY 1992			
12VDC to 240VAC inverter			
- main board	920039-1 •	11.15	22.30
- power board	920039-2 •	6.45	12.90
- front panel foil	920038-F •	16.15	32.30
Audio DAC - 1	920063-1 •	8.50	17.00
Optocard for universal PC I/O bus	910040 •	12.95	25.90
FM tuner - 5:			
- keyboard/display board	920005-4 •	14.40	28.80
- S-meter board	920005-6 •	3.80	7.60
- EPROM 27C256	6101	15.30	30.60
- front panel foil	920005-F •	13.20	26.40
RS232 quick tester	920037 •	5.00	10.00
Water pump control for solar power system	924007 •	7.35	14.70
Simple power supply	924024 •	5.00	10.00
Wideband active telescopic antenna	924102 •	3.25	6.50
JUNE 1992			
I²C display	920004 •	4.70	9.40
FM tuner - 4:			
- mode control board	920005-3 •	5.60	11.20
- synthesizer board	920005-5 •	10.85	21.70
Guitar tuner:			
- PCB	920033 •	10.00	20.00
- front panel foil	920033-F •	8.80	17.60
Multi-purpose Z80 card	920002 •	20.25	40.50
- GAL set (2x16V8)	6111	11.15	22.30
- BIOS EPROM 27128	6121	15.30	30.60
- software on IBM PC disk	1711	7.65	15.30
4MB printer buffer:			
- front panel foil	910110-F •	11.45	22.90
- EPROM 27C64	6041	15.30	30.60
May 1992			
Compact mains supply	920021 •	7.35	14.70
FM tuner - 3 (PSU)	920005-2 •	8.80	17.60
GAL programmer:			
- PCB	920030 •	11.15	22.30
- software: see June 1993			
NICAM decoder:			
- PCB	920035 •	15.00	30.00
- front panel foil	920035-F •	8.25	16.50
APRIL 1992			
80C32 SBC extension	910109 •	13.50	27.00
2-metre FM receiver	910134 •	10.30	20.60
Comb generator	920003 •	8.50	17.00
AD232 converter:			
- PCB	920010 •	12.35	24.70
- software on IBM PC disk	1691	7.65	15.30
Automatic NiCd charger	UPBS-1	2.30	4.60
LCD for L-C meter	920018 •	4.70	9.40
Milli-ohm meter adaptor	920020 •	4.40	8.80
MARCH 1992			
L-C Meter:			
- front panel foil	920012-F •	11.45	22.90
8751 emulator	920019 •	12.05	24.10
- EPROM 27C64 + IBM disk	6051	29.40	58.80
A-D/D-A and I/O for I²C bus:			
- PCB	920131-2 •	6.15	12.30
- software on IBM PC disk	1821	7.65	15.30
AF drive indicator	920016 •	5.60	11.20
Centronics line booster	910133 •	5.90	11.80
FM tuner (tuner board)	920005 •	21.15	42.30
MIDI optical link	920014 •	6.15	12.30
FEBRUARY 1992			
Audio/video switching unit	910130 •	11.75	23.50
I²C interface for PCs	910131-1 •	14.40	28.80
Mini square wave generator	910151 •	5.30	10.60
Switch-mode power supply	920001 •	4.40	8.80
8051/8032 assembler course:			
- EMON51 EPROM + course disk for IBM PCs (1661)	6061	20.00	40.00
- EMON51 EPROM + course disk for Atari (1681)	6091	20.00	40.00
- course disk for IBM PCs	1661	7.65	15.30
- course disk for Atari	1681	7.65	15.30
JANUARY 1992			
Build your own CD player:			
- PCB	910146 •	8.25	16.50
- front panel foil	910146-F •	12.05	24.10
Fast precise thermometer	910081 •	8.50	17.00
Low-frequency counter			
- input board	910149-1 •	5.00	10.00
- display board	910149-2 •	6.45	12.90
Mini Z80 system	910060 •	10.60	21.20
Prototyping board for IBM PCs	910049 •	21.15	42.30
PC-controlled weather station (3):			
- software on IBM PC disk (supersedes 1551 and 1561)	1641	7.65	15.30
DECEMBER 1991			
Class-A power amplifier (2)			
- protection PCB	880092-3 •	7.50	15.00
- power supply PCB	880092-4 •	7.60	15.20
µP programmable filters	910125 •	6.75	13.50
Amiga mouse/joystick switch:			
- PCB	914078 •	4.10	8.20
- GAL 16V8	6001	8.25	16.50
Safe solid-state relay	914008 •	3.80	7.60
Slave mains on/off control Mark-2	914072 •	6.45	12.90
Connect-4 software in 2764 EPROM	6081	15.30	30.60
NOVEMBER 1991			
Relay card for universal I/O interface	910038 •	12.95	25.90
Dissipation limiter	910071 •	4.40	8.80
Class-A power amplifier (1)			
- voltage amp. PCB	880092-1 •	9.95	19.90
- current amp. PCB	880092-2 •	9.05	18.10
Timer for CH systems	UPBS-2	3.80	7.60
24-bit full-colour video digitizer (extension for Archimedes project):			
- software on Arch. disk	1631	11.15	22.30
OCTOBER 1991			
PC-controlled weather station (2)	900124-2 •	3.80	7.60
Audio spectrum shift encoder/decoder	910105 •	10.35	20.70
SEPTEMBER 1991			
Timecode interface for slide control:			
- main board	910055 •	24.40	48.80
- display board	87291-9a •	4.10	8.20
- software on IBM PC disk	1611	7.65	15.30
- front panel foil	910055-F •	8.80	17.60
Asymm-symm converter	910072 •	5.60	11.20
Plotter driver:			
- software on IBM PC disk	1541	11.15	22.30
JULY/AUGUST 1991			
Multifunction I/O for PCs:			
-PCB	910029 •	24.40	48.80
- PAL 16L8	5991	8.25	16.50
B/W video digitizer:			
- PCB	910053 •	22.60	45.20
- software on Arch. disk	1591	11.15	22.30
Logic analyser - 5:			
- IBM PC disk + LA-GAL	1491	19.40	38.80
- Atari disk + LA-GAL	1501	19.40	38.80
Stepper motor board - 2:			
- power driver board	910054-2 •	28.50	57.00
LED voltmeter	914005 •	5.60	11.20
Wien bridge	914007 •	4.10	8.20
Angled bus extension card for PCs	914030 •	12.05	24.10
Sync separator	914077 •	4.40	8.80
JUNE 1991			
Universal battery charger	900134 •	9.40	18.80
Logic analyser - 4:			
- power supply board	900094-7 •	8.80	17.60
- Atari interface board	900094-6 •	12.65	25.30
- IBM interface board	900094-1 •	14.40	28.80
- PAL 16L8 for IBM i/face	5971	8.25	16.50
Digital phase meter (set of 3 PCBs)	910045-1/2/3 •	26.15	52.30
Light transceiver	UPBS-1	2.30	4.60
Variable AC PSU:			
- PCB	900104 •	6.15	12.30
- front panel foil	900104-F	16.45	32.90
Light switch with TV IR r/c	910048 •	5.60	11.20
Real-time clock for Atari ST:			
- PCB	910006 •	6.15	12.30
- software on IBM PC disk	1621	7.65	15.30
Stepper motor board -1:			
- PAL 16L8	6011	8.25	16.50
MAY 1991			
80C32/8052 Computer	910042 •	12.05	24.10
Battery tester	906056 •	4.10	8.20
Universal I/O interface for IBM PCs	910046 •	10.85	21.70
APRIL 1991			
Logic analyser (3):			
- control board	900094-5 •	18.50	37.00
MIDI programme changer:			
- PCB	900138 •	6.75	13.50
- EPROM 2764	5961	15.30	30.60
8-bit I/O for Atari:			
- PCB	910005 •	12.35	24.70
- software on Atari disk	1571	7.65	15.30
6-m band transverter	910010 •	11.45	22.90
Wattmeter:			
- meter board	910011-1 •	6.45	12.90
- display board	910011-2 •	4.10	8.20
Tektronix/Intel file converter:			
- software on IBM PC disk	1581	7.65	15.30
Dimmer for halogen lights			
- transmitter board	910032-1 •	4.10	8.20
MARCH 1991			
The complete preamplifier:			
- input board	890169-1 •	26.10	52.20
- main board	890169-2 •	39.35	78.70
FEBRUARY 1991			
Logic analyser (2):			
- Probe board	900094-3 •	5.00	10.00
Multifunction measurement card for PCs:			
- PCB	900124-1 •	28.20	56.40
- PAL 16L8	561	10.30	20.60
- software on IBM PC disk	1461	7.65	15.30
MIDI-to-CV interface:			
- 2764 EPROM	5981	15.30	30.60
RDS decoder:			
- demodulator board	880209 •	5.30	10.60
- processor board	900060 •	7.65	15.30
- EPROM 2764	5951	15.30	30.60
JANUARY 1991			
Logic analyser (1):			
- Busboard	900094-4 •	10.60	21.20
DECEMBER 1990			
Milliohmmeter	910004 •	5.90	11.80
Signal suppressor for all-solid state preamp	904024 •	4.40	8.80
NOVEMBER 1990			
Medium-power audio amplifier	900098 •	10.60	21.20
Programmer for the 8751			
- PCB	900100 •	8.25	16.50
- LC 87C51	7061	46.40	92.80
- software on IBM PC disk	1471	7.65	15.30
OCTOBER 1990			
µP-controlled telephone exchange.			
- PCB	900081 •	21.15	42.30
- EPROM 27128	5941	15.30	30.60
SEPTEMBER 1990			
Infra-red remote control	904085/86 •	7.95	15.90
JULY/AUGUST 1990			
Compact 10A power supply	900045 •	13.50	27.00
Intermediate projects	UPBS-1	2.30	4.60
Mini FM transmitter*	896118 •	5.00	10.00
Sound demodulator for satellite TV receivers	900057 •	4.40	8.80
Audio power indicator	904004 •	4.40	8.80
Four-monitor driver for PCs	904067 •	6.15	12.30
* can not be supplied to readers in the UK			
JUNE 1990			
Power zener diode	UPBS-1	2.30	4.60
MAY 1990			
Acoustic temperature monitor	UPBS-1	2.30	4.60
APRIL 1990			
Digital model train (13)	87291-10 •	4.70	9.40
Q meter	900031 •	7.05	14.10
RS-232 splitter	900017-1 •	8.50	17.00
	900017-2 •	5.30	10.60
MARCH 1990			
Digital model train (12)	87291-9 •	4.10	8.20
Video mixer (3):			
- PCB	87304-3 •	41.70	83.40
- EPROM 27128	5921	15.30	30.60
FEBRUARY 1990			
Digital Model Train (11)	87291-8 •	5.30	10.60
Reflex MW AM receiver	UPBS-1	2.30	4.60
JANUARY 1990			
Video mixer (1)	87304-1 •	32.00	64.00
Mini EPROM programmer	890164 •	8.25	16.50
All solid-state preamplifier	890170-2* •	18.50	37.00
The Digital Model train (10):			
- control program on disk	109	6.75	13.50
DECEMBER 1989			
Digital Model Train	87291-7 •	10.30	20.60
Solid-state preamp	890170-1* •	13.80	27.60
	890170-3* •	10.60	21.20
NOVEMBER 1989			
Digital Model Train (8)			
- PCB	87291-5 •	51.10	102.20
- EPROM 27C64	572	11.75	23.50